NATIONAL SCIENCE FOUNDATION
OFFICE OF POLAR PROGRAMS

NEW POWER PLANT
AND ANCILLARY FACILITIES
BUILDING 103
AMUNDSEN-SCOTT SOUTH POLE STATION, ANTARCTICA

OPERATIONS AND MAINTENANCE MANUAL

Volume I

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INTRODUCTION

This manual is intended to provide a single source of reference on the systems and equipment installed in the “New Power Plant” (Building 103).

This manual is an introduction to the operation & maintenance (O&M) of building specific systems and equipment, but is not meant to supersede the manufacturers' specifications or information. The drawings and references contained within this text are “As-Built” records edited from original construction documents and reflect the actual installed condition of building systems and equipment. Original manufacturers' drawings, schematics, specifications, and information have been utilized to the fullest extent.

This manual is divided into four (4) major divisions or sections.

- Section 1 -- **DESCRIPTIONS**: Plain language descriptions of the building infrastructure and various systems contained within the building.
- Section 2 -- **OPERATIONS**: Basic overview of the operational characteristics of the building, equipment, and systems.
- Section 3 -- **MAINTENANCE**: Specific maintenance requirements for equipment and systems.
- Section 4 -- **APPENDICES**: Provides manufacturers' O&M data, drawings, schematics, wiring diagrams, parts identification, and contractor information.

This manual should be considered a living document and enhanced throughout the life of the building. Operational characteristics, maintenance procedures, and O&M data for building equipment and systems should be updated as equipment/systems are developed, modified, and/or upgraded during the life of the building.

1 DESCRIPTIONS

1.1 GENERAL BUILDING DESCRIPTIONS

1.1.1 Building Design

The New Power Plant, ancillary substation and water treatment facility (Building 103) consists of approximately 6,105 square-feet with a 162'-8" x 40'-0" foot-print. It is contained within an enclosed corrugated metal arch enclosure measuring approximately 200'-6" in length with a 55' diameter (29' high from snow grade and a 3' extension below snow grade). The building houses all equipment required for the power generation and water treatment needs of the South Pole Station.

The New Power Plant building is elevated above a depressed snow floor surface to provide a thermal break between the cold snow and the warm building interior. This design also provides access to the building's footings for periodic structural inspection and maintenance.

Access is provided at the downwind bulkhead for future replacement of the generator sets at some point during their operational life.

A 6'-9" wide equipment removal corridor is maintained along the length of the New Power Plant, ahead of the engine generator units. This corridor provides a path for the removal and replacement of the engine generator units and/or major components. Additionally, an approximately 7' wide clear aisle between each engine generator is provided for maintenance access and servicing.

1.1.2 Building Occupancy

The facility is designed as a permanent structure with an expected life of greater than 25 years. Occupancies within the building are designated by Group & Division, as specified in the Uniform Building Code (UBC), for the various uses of the programmed spaces.

A summary of the Occupancy classifications is as follows:

- Power Generation and Control F-1
- Water Treatment F-1
- Substation F-2
- Fuel H-3
- Remote Radiator F-1
- Balance of Spaces F-1

1.1.3 Building Site and Utilities

The New Power Plant Arch and Building is located on-site adjacent and parallel to the existing Garage Arch, located on the grid southeast side. (Refer to drawing T1.0, Appendix 4.1.2.)

Communications, fuel oil, fire alarm, and other necessary utilities are routed to the facility via passageways/utilidors.

Electrical power is supplied to the “New Power Plant” facility via the power generation equipment and switchgear located within the building.

Fire Alarm / Telecommunications / Monitoring systems are routed and interconnected to the “Site Communications Center”.

Fuel oil for heat and power generation equipment is provided by means of (2) fuel oil day tanks located in the Fuel Room (Room 108), which is supplied by fuel oil supply distribution lines originating from the “Fuel Storage Facility”.

Collection and temporary storage of the wastewater from toilets, urinals, and lavs is accomplished with local waste water storage tank systems.

Domestic water is provided by (2) local treated water storage tanks located in the Water Treatment Room (Room 102) and supplied through a pressurized booster pump system.

Well/Raw water is routed between the Water Treatment Room (Room 102) and the Rodriguez Well, which in conjunction with the emergency snow melter, provides the water necessary for the treated water system.

Waste Heat is provided by the engine generators and is connected into a distribution system to supply waste heat to the existing facilities. An auxilary boiler provides supplemental building heat during off-line periods of the waste heat system.

1.1.4 Building Room Schedule

1ST FLOOR	
ROOM NAME	**ROOM #**
Vestibule	Rm. 101
Water Treatment	Rm. 102
Accessory Room #1	Rm. 103
Accessory Room #2	Rm. 104
Restroom	Rm. 105
Substation	Rm. 106
Hallway	Rm. 107
Fuel	Rm. 108
Control	Rm. 109
Power Generator	Rm. 110
Remote Radiator	Rm. 111

1.2 ARCHITECTURAL / STRUCTURAL SYSTEMS

1.2.1 Arch Systems

1.2.1.1 Arch Enclosure

The New Power Plant Arch enclosure is a non-heated structure and functions as a non-thermal insulator from the polar environment for the New Power Plant building enclosed within. The Arch enclosure is interconnected to the adjacent Archs via enclosed personnel passageway / utilidors (unheated), which are linked to the other subsurface structures.

1.2.1.2 Bulkhead Walls

The “bulkhead” completes the weather enclosure of the New Power Plant Arch. The bulkheads have a soft connection at the arch, which allows the arch to deflect under the accumulating snow and allows movement due to changing ice field conditions. Additionally, the bulkheads are designed to resist the lateral pressure from wind and the accumulating snow. The downwind bulkhead of the facility is designed with removable panels to allow access to the generators within to facilitate replacement as required.

1.2.2 Building Systems

1.2.2.1 Foundation System

The foundation system consists of a series of footings founded on compacted snow. The footings are located at a level below that of the arch footings and are within 1 foot of the height of the bottom of the arch footings. The foundation design includes provisions for periodic leveling of the building (required as a result of settlement of the footings). Jack points are located adjacent to the columns under the main girders. These points are short structural sections with a thermal break that extend just below the soffit insulation panels. (Refer to structural steel shop drawings, Appendix 4.2.1.1.1.)

1.2.2.2 Floor Framing System

The floor framing system is comprised of floor modules of steel plate over wide flange steel beams, insulated soffit (underside of building) panels, and fiber cement board. Steel channels are provided at each end of the modules to provide lateral stiffness to the steel framing. The steel floor plate extends the width and length of the module stopping at the center of the wide flange beams and channels.

Running down both ends of the New Power Plant building, within the Arch, are fiberglass grating walkways.

The fiberglass grating is supported on aluminum framing. The framing is supported from the building foundation columns and beams below the soffit panels and the arch footings.

1.2.2.3 Roof Framing System

The roof framing system consists of steel wide flange beams and girt sections spanning between steel wide flange girders and columns supporting the insulated roof panels. The girt sections provide support for both roof and wall panels at the chamfer in the roof. The insulated panels provide the structural support for the lateral load in the longitudinal direction.

1.2.2.4 Stairs

Roof access to the New Power Plant is provided by an alternating tread stair adjacent to the main entrance. This type of stair is easier to use than the conventional ship’s ladder, yet uses only a similar amount of space.

1.2.2.5 Roof Walkway

The roof walkway is comprised entirely of 4’-0” fiberglass grating and is accessed from the alternating tread stair. The walkway runs the length of the New Power Plant roof and allows access to the generator exhaust piping and silencers.

1.2.3 Windows and Doors

Door types, function, sizes, and required resistive fire ratings are as indicated on the “Door Schedule” and “Door Types” details referenced in the New Power Plant design drawings. (Refer to drawing A12.0, Appendix 4.1.3.)

New Power Plant building exterior doors consist of insulated double swing cold storage type doors. All building exterior insulated doors have a heat traced perimeter, sill and frame.

Building interior doors include non-insulted single/double swing type doors. A sound insulated door is provided between the hallway and the Power Generation Room.

Door hardware and operating mechanisms are in accordance with ANSI/BHMA specifications. Hardware for fire doors is in accordance with NFPA 80 and hardware for exit doors is in accordance with NFPA 101. Door locks are not required except for a privacy lock at the toilet room door.

Windows consist of fixed double insulating glass listed and labeled for 45 minute fire-protection rating. Sound insulated windows are provided between the control and power generation rooms.

1.2.4 Thermal Insulation

The New Power Plant Arch functions as a non-thermal insulator from the polar environment. The New Power Plant building is elevated above the snow surface to provide a thermal break between the cold snow and the warm interior of the building. The building is enveloped at roof, walls, and soffit by insulated panels. The insulated panels consist of an expanded polystyrene (EPS) core with oriented strand board (OSB) on both sides. A self-sealing (healing) type vapor barrier is applied to the interior surface of the insulated panels.

The insulation R-values are as follows:

- Walls R-50
- Roof/Ceiling R-70
- Floors/Soffit R-70

Interior wall & ceiling partitions are insulated with blanket (batt) fiberglass Type I insulation with a thermal resistance value of R-19. Foamed-in-place insulation is utilized where blanket insulation is not accessible.

1.2.5 Exterior Finishes

The exterior finish material of the New Power Plant building is composed of pre-finished aluminum faced plywood panels. The exterior facing is factory finished with a white siliconized polyester coating.

1.2.6 Interior Finishes

1.2.6.1 Wall / Ceiling Support Systems

A typical support system for 1-hour rated non-combustible walls & ceilings consists of 3-5/8” metal studs @ 16” on-center with 5/8” Type-X gypsum board on each side and 1/4” FCB over the gypsum board. A double layer of Type-X gypsum board is utilized in a typical 2-hour partition.

1.2.6.2 Gypsum Board

5/8” Type “X” gypsum board is typical for all wall & ceiling construction and/or where application of gypsum board surfaces is required throughout the New Power Plant facility. Joint treatment consists of an application of joint tape in conjunction with an embedding all-purpose or topping compound. Where textured finishes are required, a standard machine-applied light orange peel texture is spray finished.

1.2.6.3 Floor Finishes

Floor types/finishes are as indicated on the "Room Finish Schedule". (Refer to design drawing A9.0, Appendix 4.1.3.)

Non-slip surfaces are applied to all flooring areas except those indicated as sheet vinyl flooring. A coarse non-slip epoxy surface treatment is provided.

Sheet vinyl flooring is provided in the control room and restroom areas.

1.2.6.4 Wall Finishes

Wall finishes are as indicated on the "Room Finish Schedule". (Refer to design drawing A9.0, Appendix 4.1.3.)

Walls & ceilings are comprised of non-combustible materials. Typical wall finishes consist of field applied painted finishes or wainscot materials on gypsum board. Acoustic foam sheeting is provided in the control room for sound control.

1.2.6.5 Base Finishes

Base finishes are as indicated on the "Room Finish Schedule". (Refer to design drawing A9.0, Appendix 4.1.3.)

A watertight base closure at the overall perimeter is provided where steel plate flooring meets the exterior wall of the building.

Rubber topset base is provided as standard building base finishes in all rooms with the exception of the Fuel and Remote Radiator Rooms.

1.2.7 Interior Specialties / Fixtures

1.2.7.1 Signs

Interior signs are provided for instructional use. Acrylic sheet material or aluminum/stainless steel compatible with the applied sign stock is utilized.

1.2.7.2 Toilet Accessories

Toilet accessories and building hardware are provided as follows:

- Toilet Tissue Dispensers (surface mounted): Roller mounted on three support brackets for two rolls, spring actuated.
- Paper Towel Dispenser (surface mounted): Stainless steel, Type III (C-fold or Multi-fold Towels). Dispenses 400 C-fold or 525 multi-fold paper towels.

- Soap Dispenser: Integral refillable container with 40 fluid ounce capacity. Stainless steel suitable for dispensing liquid soaps, grease removers or detergents.
- Mirrors: Class 2, Style E, Grade 2, electrocopper plated. Equipped with integral shelf for the full width of the mirror.
- Mop and Broom Holder: 24” long holder of 22 gauge stainless steel in No. 4 satin finish, with three spring-loaded rubber cam anti-slip mop/broom holders.
- Parka Hooks: Type 304 stainless steel. 1” wide x 6 ¼” high and projects 3” from wall.

1.2.7.3 Miscellaneous Specialties

- Fire Extinguishers: Multi-purpose dry chemical type (UL-rated 4-A:30-B:C) are located adjacent to all exits and utilized within all flammable hazard areas throughout the New Power Plant facility. Fire extinguishers are wall mounted approximately 5’-0” A.F.F.
- Daylighting Tubes: Daylighting tube assemblies consist of a 10” diameter, high-impact acrylic dome, housed with a curved metal reflector, mounted to the roof on a flat flashing collar. The daylighting tubes provide natural light in the Arch during the summer months.

1.3 CONVEYING SYSTEMS

1.3.1 Rolling Gantry Hoists

A 10-ton rated rolling gantry hoist is provided to accommodate the disassembly, lifting, removal and replacement of engine components during overhauls, scheduled and unscheduled maintenance activities. The rolling gantry straddles the engine generator on each side. Use of the gantry requires removal of vertical piping spool pieces to facilitate the range of movement.

1.4 MECHANICAL SYSTEMS

1.4.1 Heating Generation and Distribution Systems

1.4.1.1 Fuel-Fired Boilers

Auxiliary heat generation for the New Power Plant facility is provided by a AN-8 fired hydronic (hot water) boiler. The boiler is a low pressure, forced draft, wet base, cast-iron sectional boiler. Primary heating to the building is provided by a heat exchanger connected to the waste heating system. Should the waste heating system fail, the auxiliary boiler is sufficient to provide energy requirements to prevent equipment damage within the New Power Plant building and maintain the building at a workable temperature.

1.4.1.2 Perimeter Heating System

The building perimeter heating system utilizes a circulation loop of heat transfer fluid (60/40 mixture ethylene glycol), heated by a heat exchanger connected to the Station waste heat system, and transported by duplex pump sets. The pump sets circulate flow of heat transfer fluid to terminal units (unit heaters, cabinet unit heaters, finned tube heaters) and to heating/pre-heat coils of selected air handling units (AHU's). (Refer to drawing M8.1, Appendix 4.1.3.)

Back-up heat and circulation to the perimeter heating system is provided through the auxiliary boiler and duplex pump sets.

1.4.1.3 Waste Heat Connection and Distribution

The waste heat recovery system utilizes engine generator set stack gas and jacket water waste heat to distribute to the district heating loop. The main distribution loop has two primary pumps that circulate heated glycol throughout the Station to all connected facilities with their respective flat plate heat exchangers.

1.4.2 Ventilation and Air Systems

1.4.2.1 Exhaust Systems

Individual exhaust fans are provided for various spaces throughout the New Power Plant building. All exhaust fans discharge through the building envelope and through the exterior Arch roof to the outside environment.

Exhaust fans serve the following building spaces:

- EF-1: . . . . Restroom
- EF-2: . . . . Fuel

1.4.2.2 Make-up Air/Supply Systems

Supplying make-up air to replace that exhausted is a primary component of the supply air system. In addition, the air supply ventilation system maintains building air quality, provides combustion air, reduces drafts, and reduces infiltration through slight pressurization of spaces.

The AHU's provide the make-up air, engine/boiler combustion air, ventilation, and air tempering/cooling requirements for the New Power Plant building spaces. Outside air for uses in the building is supplied through the floor and ducted to the individual air handling units.

Air Handling Units serve the following building spaces:

- AHU-1 and AHU-2. . . . . Power Generation ventilation

These units are located in the Power Generation Room and provide combustion air to the engine generators and the auxiliary boiler as well as make-up air for exhaust fans EF-1 & EF-2.

- AHU-3 . . . . Control Room ventilation

This unit is located in the Control Room and provides ventilation, cooling and positive pressurization for the Control Room and Accessory Room.

- AHU-4 . . . . .Substation ventilation

This unit is located in the Substation Room and provides cooling air to the Substaion.

- AHU-5 . . . . Control Room ventilation

This unit is located in the Control Room and transfers make-up air provided by AHU-1 & AHU-2 to EF-1 and EF-2.

The heating coils in the air handler units are designed only to temper the air, but not to provide heating.

1.4.2.3 Engine Room Combustion and Ventilation Air System

The air handling units (AHU-1 & AHU-2) located in the Power Generation Room are provided to accommodate the cooling requirements of the Power Generation Room. In addition to space cooling, the AHU's provide outside air for engine combustion air, boiler combustion air, and make-up air for exhaust systems.

1.4.2.4 Remote Radiator Cooling System

To eliminate the potential for damage when the heat recovery system is off-line, or if the waste heat is not being used, remote radiators are utilized to reject heat from the jacket water.

Make-up air for the remote radiator fans is supplied through the ceiling of the Remote Radiation Room. Outside and return air openings are provided to control outside air and air mixing. The radiator exhaust opening exits through the Arch bulkhead and terminates above the peak of the Arch.

1.4.2.5 Arch Ventilation

Outside air is brought into the Arch through the upwind bulkhead via an outside air hood. There are no fans or control devices installed in the air opening. The outside air intake is provided to supply air to the air handling units which are ducted through the building floor spaces.

1.4.3 Plumbing Systems

1.4.3.1 Domestic Water System

Domestic water for utilization within the New Power Plant building is contained in two (3,000 gallon nominal) water storage tanks located in the Water Treatment Room. These water storage tanks also serve as the Station domestic water supply. An adjacent booster pump system pressurizes the domestic water piping associated with the system.

1.4.3.2 Waste/Vent System

Waste from the restroom's water closet, urinal, and lavatory drain by gravity to a wastewater holding tank below the Toilet Room floor. The wastewater holding tank has a capacity of 800 gallons nominal. Waste is pumped from the tank through a Kam-lock connection (located in the utility access chase at the downwind end of the Arch) via a tank mounted discharge pump.

A sparging system injects air into the waste holding tank though a solenoid valve on a compressed air line. This subsystem is designed to keep the waste from becoming anaerobic and prevent solidification of the waste during storage periods.

1.4.4 Fire Protection System

A Carbon Dioxide (CO_2) fire protection system is provided for fire suppression needs within the New Power Plant. Fire protection coverage is provided for the Fuel Storage Room and for each individual engine generator unit within the Power Generation Room. A zoned system is provided. Independent zones include Fuel Storage Room (total flooding) and Generators 1-4 (local application).

The zoned system is divided into the following zones:

Zone #	Description
• 1	GEN-1 / Local
• 2	GEN-2 / Local
• 3	GEN-3 / Local
• 4	GEN-4 / Local
• 5	Fuel Storage Room / Total Flooding

The CO_2 agent is supplied to the fire suppression zones through a manifold piping system originating from cylinder banks within the Substation Room. (3)-100 lb. “main” discharge and (3)-100 lb. “reserve” discharge CO_2 cylinders are provided for the Fuel Room, and (21)-100 lb. “main” discharge and (21)-100 lb. “reserve” discharge CO_2 cylinders are provided for the engine generators.

The system is activated automatically by multiple detectors indicating a fire condition in the affected space. Emergency pull stations are provided adjacent to the cylinder banks to facilitate manual activation of each zone.

1.4.5 Compressed Air System

The compressed air system serves piped air outlet connections located throughout the New Power Plant building.

Air outlet stations are typical for each location and consist of a long drip leg with blowdown valve, isolation valve, regulator (with gauge), filter, quick disconnect coupling, and automatic lubricator. Additionally, the compressed air system serves as an air source for the engine generator exhaust soot catalyst injectors and the sparging air system for the waste storage tank.

Air delivery is provided by a two-stage, 2 horsepower, 480 volt, 3-phase, reciprocating air compressor. A vertical 80 gallon receiver tank is utilized to minimize floor space within the Power Generation Room. A drip pan is located below the air compressor to facilitate draining of condensate. A moisture separator with drain, pressure regulator, pressure gauge with isolation cock, coalescing filter with drain, and long drip leg with blow-down valve are connected to the discharge piping of the air compressor and serve to protect the downstream ancillary piping and equipment.

1.4.6 Breathing Air System

A supplied air breathing air compressor is located in Accessory Room #2. The compressor supplies breathing air to replenish Self Contained Breathing Apparatus (SCBA) bottles upon depletion of the air within the tank/bottle.

1.4.7 In-Plant Fuel Oil System

AN-8 fuel oil is supplied to the New Power Plant building via the main fuel oil circulation loop originating from the Fuel Storage Facility.

Two fuel storage day tanks (1,000 gallon nominal) are located in the Fuel Room. The two tanks are interconnected and may be isolated from each other via associated valving. Tank capacity includes 6 hours of emergency fuel supply in excess of the 24 hours of peak fuel consumption supply.

Fuel is transferred to the four generators and auxiliary boiler through individual suction lines and returned through a common return line. Fuel oil is filtered with in-line filters located on the supply side of the generators and auxiliary boiler. Safety valves are provided at branch equipment and main supply locations. Fuel is metered from the main circulation loop by a fuel oil meter adjacent to the day tanks. Individual fuel meters are provided to meter fuel at each piece of equipment being supplied.

1.4.8 Engine-Generator Set / Engine Systems

1.4.8.1 Diesel Engine Generators

Station electrical energy production is provided by four diesel driven generators. Three of the engine/generator units are identical and provide base load power production, each with a net prime rating capacity at site conditions of 750 kW and supplying 277/480 volts, 3-phase, 4-wire, 60 Hz, wye ac output. The fourth engine/generator provides peak load power production with a net prime rating capacity at site conditions of 250 kW and supplying 277/480 volts, 3-phase, 4-wire, 60 Hz, wye ac output.

Each engine/generator unit is individually skid mounted, jacket water cooled, and configured to burn AN-8 fuel at an altitude of 12,000 feet. To protect against destructive vibration effects and reduce overall noise generation, each unit is mounted on vibration isolators. The generators are arranged side-by-side in a single row on an approximately 14’-8” spacing. The spacing provides a clear aisle between each engine/generator for maintenance access and servicing.

The diesel engines are four-cycle, turbocharged, intercooled and designed for continuous electrical duty. Each engine is equipped with an adjustable speed sensing isochronous governor which includes provisions for adjusting speed while the unit is in operation. The engines are also equipped with protective devices to initiate shutdown. The shutdown devices are direct in action and are independent of the governor. In conjunction with the shutdown devices, each engine contains alarm devices to actuate an alarm on the associated engine control panel.

1.4.8.2 Cooling System

The generator engines are provided with an integral coolant pump driven from the engine. Each pump has the capacity to circulate the required flow of coolant through the system to remove the total heat rejected from the engines.

The jacket water system incorporates waste heat recovery from all available water cooled engine components including: engine jacket water, engine oil cooler, and turbocharger aftercooler.

The jacket water heat rejection loop consists of duplex external circulating pumps, waste heat recovery heat exchangers, remote air cooled radiators expansion provisions, glycol make-up provisions and control valves.

The heat recovery side of the jacket water heat recovery heat exchangers is connected to the Station main heat recovery loop through automatic control valves to allow automatic selection of the operating engine generator unit.

To eliminate the potential for generator damage when the heat recovery system is off-line, or if the waste heat is not being used, remote radiators are utilized to reject heat from the jacket water.

1.4.8.3 Stack Gas

Engine/generator stack gas combines engine sound attenuation silencers with exhaust gas heat recovery. Heat recovery silencers are located adjacent to each generator. Non-heat recovery silencers are located on the roof above. Stack gas heat recovery takes place using an exhaust gas heat exchanger. These heat exchangers are designed to transfer heat from the hot exhaust gases to the liquid heat transfer fluid.

Engine exhaust heat recovery consists of a hydronic heat recovery silencer, duplex circulating pumps, expansion provisions, glycol make-up provisions and control valves. The engine exhaust heat recovery loop is connected to the Station heat recovery loop in a primary-secondary pumping arrangement to allow off-line isolation.

1.4.8.4 Lubricating Oil System

To increase the engine/generators ability to lubricate the diesel engine cylinders and piston rings and in order to minimize frictional and abrasive wear, deep oil sumps are provided. The increase in nominal capacity effectivity doubles the life of the lubrication oil.

To further enhance service life, a continuous, centrifugal, lube oil purification system is used to process engine/generator lubrication oil.

The system is manifolded to each generator. With this type of system, the lube oil change for each engine can be increased significantly. The duplex lubrication oil filters that are provided standard on the engine/generators also benefit from the lube oil purification system through extended filter replacement intervals.

To reduce the potential of cross contamination, the lubrication oil system is equipped with in-line control valves to isolate the generator units from each other and allow processing of only one engine at a time. The extent of cross contamination should have no significant impact on the engine oil quality or sampling and trend analysis.

1.4.9 Water Treatment, Storage and Distribution

1.4.9.1 Treated Water System

In general, water is generated by melting ice or snow, filtered to remove any particulates, disinfected, and treated to neutralize pH balances. It is then distributed throughout the domestic water system. The main source of water is the Rodriguez Well. Water is pumped from the well to the Water Treatment Room within the New Power Plant.

Raw water is pumped from the existing Rodriguez Well where it passes through three limestone contactors for pH adjustment. Return water is sent through a plate heat exchanger and back to the well head.

Treatment consists of the addition of sodium bicarbonate for alkalinity adjustment. The water is then passed through a 5 micron filter followed by a carbon filter for taste/odor adjustment and suspended particle removal. Disinfection is accomplished with calcium hypochlorite. Contact time is provided in a chlorine contact chamber. Static in-line mixers assure that the chemicals are evenly disbursed throughout the raw water flow. The treated water is stored in two 3,000 gallon stainless steel storage tanks.

Domestic distribution pressure is maintained by a set of duplex pressure pumps and a pneumatic pressure tank.

A emergency snow melter is mounted on skids and may be towed into position near the New Power Plant in the event a supplemental water supply is required. It can be connected to the heating glycol lines and snow deposited in it. As snow melts it will pool at the bottom of the tank. The water may be drawn from the tank and pumped into the regular treatment process.

1.4.10 Control Systems

1.4.10.1 Direct Digital Control Systems

The Direct Digital Control (DDC) system provides automatic temperature control and field monitoring of ancillary control systems utilizing field programmable micro-processor based units. Control systems consisting of thermostats, control valves, dampers/operators, indicating devices, interface equipment and other accessories required to operate mechanical systems are served by the DDC system.

The Central Host System (CHS) is located within the New Power Plant and monitors the status of the satellite control units. The CHS can also alter and control the Distributed Controllers.

1.5 ELECTRICAL SYSTEMS

1.5.1 Interior Distribution System

1.5.1.1 Electrical Distribution System

Electrical branch circuits contained within the New Power Plant building are primarily surface mounted and routed in electrical metallic tubing (EMT) conduit. (Minimum conduit size = ¾” diameter trade size.) Where raceways cross thermal breaks, sections PVC conduit are inserted.

Flexible conduits are used for connecting the electrical distribution system to vibrating or rotating equipment to isolate vibrations from the structure. Flexible metal conduit is also utilized where raceways cross construction joints.

Enclosed steel cable tray is provided for routing of communication cables.

Conductors of copper wire, type XHHW (75 - 90 deg. C. rating) are utilized for all branch/feeder supply circuits. All branch circuits include an equipment grounding conductor which terminates on the ground bus of the panelboard and/or switchboard.

The main grounding point which serves as the source for the equipotential reference plane for the Station is known as the “area ground point” (AGP). The AGP is bonded to the generator frames and neutrals. Copper grounding conductors are extended from the AGP to the other new Station structures to complete the equipotential reference plane.

General receptacles throughout the facility are 20 amp, 125 volt duplex type only. Outlets of any configuration located outside the New Power Plant building are GFCI and weatherproof type.

1.5.1.2 Panelboards

New Power Plant building panelboards consist of 120/208 volt, 3-phase, 4-wire or 277/480 volt, 3-phase, 4-wire, circuit breaker/branch circuit type. Panelboards are typically main lug only configuration, have solid (full) neutrals, and include doors with hinges & keyed locks. A separate ground bus is provided within each panelboard for terminating the local ground wires from branch circuits, as well as providing a bonding point for metallic surfaces throughout the area.

Panelboards are located throughout the Power Plant in sufficient quantity and at points to supply loads without excessive voltage drop and to keep the distribution system efficient with low losses.

1.5.1.3 Motor Control Centers

Motor control centers are the primary locations of motor starters for the equipment within the New Power Plant building. The motor control centers are front accessible and are rated at 277/480 volts, 3-phase, with a short circuit rating of 100,000 amperes rms symmetrical at 480 volts.

Motor controllers combined with motor circuit protection type circuit breakers (in lieu of fused disconnects) are contained in common enclosures. Locking disconnect handles for electrical maintenance safety are also provided. Half-size, full voltage, non-reversing (FVNR) motor starters are typical for all motor loads not requiring variable frequency drives (VFD) or soft start controllers. For motors 5 HP and above, soft starting motor starters are used unless a FVNR controller is recommended by the manufacturer.

1.5.1.4 Uninterruptible Power Supplies

An 8 KVA, 120/208 volt, 1-phase input and 120/208 volt, 1-phase output uninterruptible power supply (UPS) is provided to supply continuous power to DDC/CMS, telephone/PA, and computer networking systems. In the event of interruption of normal power to the facility, the UPS has battery capacity to operate at full load for 20 minutes. The UPS includes: a rectifier/charger to maintain battery charge and to provide input to the inverter, an inverter to provide power to the load, a static switch to transfer load automatically between utility power and inverter power, and a manual bypass switch for maintenance.

1.5.2 Power Generation and Distribution

1.5.2.1 Unit Substation

A new 4,160 volt integral unit substation is located within the Substation Room and provides electrical service voltage for the feeders supplying the Dark Sector. The substation is provided with a primary rating of 277/480 volts, 3-phase, 4-wire, 60 Hz, and a main bus ampacity of 800 amperes (continuous). The secondary (outgoing section equipment) is derived from a 500 kVA transformer and delivers 4.16 kV, 3-phase, 60 Hz electrical power with a main bus ampacity of 100 amperes (continuous).

1.5.2.2 Distribution Switchboards

The distribution switchboards PMDE - “Primary Main Distribution Equipment” - and RMDE - “Redundant Main Distribution Equipment” - provide primary and redundant electrical power to the Station loads.

Each distribution switchboard is supplied by the “Generator Control Master” (GC-M) and provides a primary rating of 277/480 volts, 3-phase, 4-wire, 60 Hz, and a main bus ampacity of 2,000 amperes.

The PMDE contains circuit breakers for the protection of the distribution feeders which interconnect the electrical feeders to the output circuit breakers of the RMDE. The RMDE provides circuit breakers for the protection of the branch feeders for the Station electrical service distribution equipment. Tie circuit breakers are provided to interconnect the electrical buses of the PMDE and the RMDE.

The circuit breakers utilized in PMDE & RMDE are an electronic-trip, molded case type with a microprocessor-based, true rms sensing design. Each circuit breaker is equipped with a push-to-trip button to mechanically operate the circuit breaker tripping mechanism.

1.5.2.3 Automatic Paralleling Switchgear / Generator Controllers

The “Generator Control Panels” (GC-1 - GC-4) contain all instrumentation and controls for controlling and monitoring each engine/generator unit. The control panels include provisions to monitor and control electrical performance (volts, amps, frequency, kW, etc.), monitor and annunciate alarm conditions, and start/stop the respective units. Each generator’s output circuit breaker is contained within the respective generator control unit. The generator control panels are identical in arrangement, size, capacity and features. GC-1 also contains a synchronizing scope on a hinged cover to permit manual synchronizing of the generators from the generator controller location.

The “Master Generator Control Panel” (GC-M) provides the controls, sensors, instrumentation, motorized circuit breakers, and synchronizing bus to facilitate automatic paralleling of the engine/generators. Overall performance instruments, synchronizing relays, protective relays and indicators to permit paralleling of the units are contained within the GC-M. The GC-M switchgear also contains the output circuit breakers to the PMDE and RMDE as well as the components to provide inter-operation and control of the individual generator switchgear/control sections associated with the four generators.

1.5.2.4 Power Conditioning Equipment

New Power Plant power conditioning equipment consists of transient voltage surge suppression (TVSS) and UPS for local power quality to the control room.

A TVSS is contained within each of the distribution switchgear (PMDE and RMDE) to provide clamping of spikes in the Station electrical power.

Additionally, the potential transients and noise expected to be encountered using the equipotential reference plane will be cleaned-up through repeated cycles through the TVSS units.

1.5.2.5 Dry-Type Transformers

Dry-type transformers provide a means of modifying the electrical power and voltage to meet equipment and electrical distribution requirements. Transformers are air cooled dry-type, and contain shielded isolation. Isolation type transformers are provided to reduce any harmonics transmitted to the secondary windings. Continuous copper windings are utilized to provide increased efficiency. Transformers are mounted on isolation pads to prevent transmitting vibration to the building structure.

1.5.3 Lighting

Arch Lighting: The Arch interior is illuminated with two systems. The first system utilizes daylighting, which is accomplished through the use of light tubes. The light tubes consist of a chimney tube of aluminum whose interior is finished in polished specular aluminum or metallized plastic mylar film. The top extends above the Arch roof and terminates in a collector dome that reflects light striking it at any angle down into the tube and transmits the light to the Arch interior. The second Arch system utilizes incandescent enclosed luminaires mounted on the exterior of the New Power Plant building. The fixtures are a heavy duty, vapor tight fixture with cast guard, neoprene gasketing and glass globe. These fixture types are also utilized within the Radiator Room due to low ambient temperatures.

Emergency lights within the Arch are remote head type, mounted on the exterior walls of the New Power Plant building, and supplied from batteries located within the building interior.

Non-powered, self-luminating exit signs are utilized at all egress points within the Arch.

New Power Plant Building Lighting: Interior lighting is supplied by industrial fluorescent luminaires with wire guards, and is pendant or chain mounted to provide illumination on building and equipment surfaces. All fluorescent lighting is provided with F32T8 lamps and magnetic ballasts for efficiency and reduced EMI/RFI. Locations of luminaires within the Generator Room and other spaces are adjusted as required in order to accommodate the significant amounts of mechanical, electrical, and various equipment located on and near the ceilings.

Emergency lights for interior spaces (except Radiator Room) are self-contained units with integral batteries and lighting heads to provide illumination for emergency egress. Interior exit signs are fluorescent type for low energy consumption with integral batteries for emergency function.

1.5.4 Heat Trace

Electric heat trace within the New Power Plant building is provided for the following systems or locations subjected to exterior environmental conditions:

- Plumbing Vent
- Well Water Supply/Return
- Forced Mains/Discharge
- Domestic Cold Water Supply/Return
- Raw Water Supply
- Glycol Heating Supply/Return
- Emergency Fuel Connection

Heat trace consists of self-regulating, self-limiting cabling with thermoplastic insulation, parallel conductors, and a nominal output of 10 watts/linear foot.

1.5.5 Signal Systems

1.5.5.1 Telephone

Surface wall mounted telephone outlets have been provided in the Vestibule, Control Room, and Water Treatment Room areas. A high intensity strobe light with warbler is provided in the Generator Room due to the high noise area. Telephone supply conduits (3/4”) are routed from each telephone outlet to the main telephone/data terminal board, which is located in the Control Room.

The telephone communication system is interconnected with the communications hub building in the BioMed Arch via a 50-pair cable to the New Power Plant facility. The ability to extend/connect future buildings to the Station telephone communication system has been integrated into the New Power Plant system.

1.5.5.2 Public Address System

A public address system is provided within the New Power Plant facility to support local paging and fire alarm annunciation. The PA amplifier/sound system control cabinet is located within the Control Room.

The PA system is equipped with a telephone paging relay for dial-in paging. A fire alarm control panel interface module is provided to broadcast alarms over weather-proof horns located within the Power Plant Arch.

Speaker zones are provided with attentuators to permit volume adjustment of each zone. New Power Plant building PA is zoned as follows:

Zone #	Description
1	Corridor
2	Generator & Radiator Rooms
3	Substation Room
4	Fuel & Water Treatment Rooms
5	Arch
6	Control Room
7	Spare (Future)
8	Spare (Future)

1.5.5.3 Local Area Network (LAN)

Surface wall mounted LAN/computer outlets are provided in the Control Room of the New Power Plant building. LAN/computer supply conduits (3/4”) with twisted pair conductors are routed from each LAN/computer outlet to the main telephone/data terminal board, which is located within the Control Room.

The LAN communication system provides network services via a ??-?? fiber optic cable interconnected with the communications hub building within the Bio-Med Arch. The ability to extend/connect future buildings to the Station LAN system has been integrated into the system.

1.5.5.4 Video Surveillance System

The ability to view blocked or obstructed areas within the Power Generation Room is provided by the video surveillance system. The system permits direct visual observation of areas by the Operator from the Control Room. Use of a video cassette recorder (VCR) provides a record of developing events.

The system consists of a power supply, a controller, a sequencing switcher, a time-lapse VCR, cameras and a color video monitor. The components are interconnected via fiber optic cable which is routed in the cable trays. Cameras are located to provide views to the Operator of equipment otherwise blocked from vision from within the Control Room. The view seen on the video monitor is simultaneously recorded on the time-lapse VCR. The ability to provide additional cameras in the future has been integrated in the system.

1.5.5.5 Closed Circuit Television (CCTV) (Future)

1.5.5.6 Fire Detection and Alarm Systems

The New Power Plant building fire detection and alarm system is a microprocessor based, addressable type system which is interconnected with the Station communications center. This system permits simple station-wide interconnection while maintaining addressibility. The use of an addressable system also enhances the ability of the required pre-discharge alert for the Carbon Dioxide Suppression system.

The Fire Alarm Control Panel (FACP) is located within the Control Room. The control panel's annunciation features are augmented with a graphics annunciator with LEDs which graphically indicate the alarmed zone.

Interconnection of the FACP with the CO_2 system discharge valves is provided to facilitate automatic discharge and annunciation of the carbon dioxide system.

Manual pull stations are located at all exits from the interior of the New Power Plant building.

Photoelectric type smoke detectors are used in conjunction with sampling tubes to sense products of combustion in the return air streams of air-handling units. Smoke detectors are also used in areas not subject to frequent visits by occupants or where the possibility exists of incipient combustion. Heat detectors are fixed-temperature / rate-of-rise type in warm areas and fixed-temperature type in areas where temperatures may change quickly.

In potentially high-noise areas, such as the Generator Room, visual stations are provided to ensure visual notification of alarms to the occupants within the area.

Arch fire detection and alarms consist of weatherproof heat detectors and manual pull stations. Weatherproof speakers from the public address system located within the Arch are interconnected with the fire detection and alarm system via an interface module and broadcast alarms generated by the FACP.

Fire alarm generation and annunciation for the New Power Plant building is divided into the following zones:

Zone #	Description
• 1	Generator #1
• 2	Generator #2
• 3	Generator #3
• 4	Generator #4
• 5	Fuel Room

- 6 . . . . Control Room & Corridor
- 7 . . . . Power Generation Room
- 8 . . . . Remote Radiator Room
- 9 . . . . Substation Room
- 10 . . . . .Water Treatment, Accessory, & Toilet Rooms
- 11. . . . . .Power Plant Arch
- 12 . . . . .Air Handling Units
- 13 . . . . Spare
- 14 . . . . Spare

2 OPERATIONS

2.1 GENERAL BUILDING OPERATIONS

The New Power Plant (Building 103 and Arch) embodies a facility that provides electrical power generation, primary heating energy (via waste heat recovery), and water treatment services for the South Pole Station. Inside the New Power Plant are various architectural, mechanical and electrical systems required to maintain the building infrastructure and support the activities within. A basic overview of the operational characteristics of the building elements, equipment and systems is contained in these Operations sub-sections.

2.2 ARCHITECTURAL / STRUCTURAL SYSTEMS

2.2.1 Building Systems

2.2.1.1 Foundation Leveling/Jacking

In order to maintain proper operation of building systems and components (i.e.; doors, plumbing drains), provisions for periodic building leveling have been incorporated into the foundation design. Jacking points located under the soffit of the building adjacent to each support column are provided.

Building settlement is monitored by the site surveyor during the summer season. To facilitate the extent of building settlement, Temporary Benchmarks (TBM) for the New Power Plant Building have been established based on elevations transferred from the NCEL benchmark located inside the Dome. The TBM is located at the footer (Elevation = xxxft. relative to NCEL). Upon confirmation of TBM elevation, and using the modified tripod, the instrument is positioned within the crawlspace and the points are sighted-in.

Jacking and leveling of the building, when required, is done from the outside of the building. The threaded studs are designed to allow for jacking and temporary support of the superstructure during the leveling operations. A secondary jack support point located adjacent to the main support location is incorporated into the footing pad steel framing to allow the use of hydraulic jacks to assist if needed during the leveling operations. Each of the support points are provided with approximately 4” shim plates to allow for future adjustment either up or down after initial construction.

To accommodate localized settlement, the leveling operation can be done one or two columns at a time, if required. After-leveling, shims should be installed to transfer the bearing loads between the main plates.

If leveling of the foundation system is required based on the survey results, then hydraulic jacks are utilized at the points requiring adjustment, base plate bolts are loosened, and shims are added and/or removed as necessary to bring the foundation back into proper level alignment. Upon completion of foundation leveling, all base plate and structural bolts shall be re-torqued.

2.2.1.2 Fuel/Lube Oil Containment Sills

Each generator in the Power Generation Room has a containment sill around it. The containment sill is a piece of 3”x 3”x 1/4” angle steel welded to the floor steel of the power generation room. The steel forms a continuous lip around each generator which will contain any fuel/lubrication oil leakage or spills.

The Fuel Room also has a containment sill. This sill is made of a piece of 1/16” steel plate that runs 18” up each wall. There is a 3”x 2”x 1/4” piece of angle steel welded at the base of the plate. This angle steel is continuously welded to the steel floor forming a seal. At the doorway there is a piece of steel 1/4” thick and 18” high with two pieces of 3”x2”x 1/4” angle steel welded on both sides. The angle steel is welded to the floor, forming a seal. This containment sill acts as a barrier to prevent fuel oil from spreading throughout the plant in the event of leakage and/or spill.

2.2.2 Windows and Doors

2.2.2.1 Windows

The New Power Plant has two sets of windows inside the plant, both in the Control Room. The Control Room Operator will use these windows to observe the Power Generation Room from behind a sound-dampening barrier.

The windows have an STC rating of 55. The window on the downwind side of the room is made up of three 3’x5’ windows. The window on the hallway side of the room is made up of two 3’x5’ windows. All of the windows are fixed double insulating glass with a 45-minute fire protection rating. The window frames are of an all-welded construction.

During power generation operations, the Control Room windows provide ambient noise protection for the Operators within.

2.2.2.2 Doors

There are a variety of doors associated with the New Power Plant. All doors are standard man-doors unless noted otherwise. Most, but not all, doors incorporate smoke seals. Unless noted otherwise, all doors contain a standard passage doorknob without a lock. Restroom doors contain lockable hardware.

Exit doors contain panic hardware (horizontal bars that can be pushed to open the door without turning a doorknob) and are also noted below.

Door D2 and D3 are non fire-rated interior double doors that are wall-hinged. Both doorways are 6’x8’ and have two non fire-rated vision panes.

Doors D4, D5, and D7 are non fire-rated interior doors. All are left-hand hinged doors with a non fire-rated vision panel.

Door D8 is an interior non fire-rated wall hinged double door. The doorway is 4’x 8’6”.

Doors D6 and D9 are 60-minute fire-rated double doors that are wall hinged. Both doors have two 60-minute fire-rated vision panes. Door D9 separates the Fuel Room from the Hallway in case of fire. Door D6 separates the Substation from the Hallway in case of fire. The doorways are 6’x8’.

Doors D13 and D14 are interior 60-minute fire-rated wall-hinged double doors. They act as fire barriers on the downwind side passageway between the Garage and New Power Plant.

This doorway dimensions for D15, D16, and D17 are 6’x7’6”. Each door has a 60-minute fire-rated vision panel. Each door is 4’6” x 6’8”. They act as fire barriers on the upwind passageway from the Garage, past the New Power Plant and on to the New Elevated Station.

2.2.2.3 Sound Control Doors:

Door D10 is a sound insulated door, fire-rated for 60 minutes. This door acts as a sound barrier between Hallway 107 and the Power Generation Room. It is a double swing door hinged at the wall. The door has an STC rating of 55. The door and frame are galvanized sheet with all-welded construction.

The sound control doors protect personnel from the harmful ambient noise of power generation equipment in operation.

2.2.2.4 Cold Storage Doors

The doors are exterior steel covered composite doors, insulted with a polyurethane poured-in-place foam core material, internal wood blocking, covered on both faces with a bonded stainless steel sheet. The insulation is 8” thick, with a thermal resistance of 50, and a flame spread index of 25. Each door has a total thickness of 9.5”.

The seal around the perimeter of the doors and frames is heated with cables embedded in the gasket to prevent ice build-up from interfering with door operation. The current in the heater cables can be controlled with the 120 volt variable transformer (adjustable rheostat), which is located near the door.

The doors are equipped with multi-point latches to provide secure sealing when closed. As a safety feature, this latch has an inside release, which opens the door even if the latch happened to be locked on the outside. Self-closing cam-rise hinges are designed to close the door firmly with minimum effort.

There are three sets of cold storage doors. Door D1 is a hinged double door and the main entrance door on the upwind side of the building. The door is 6’x8’. Door D11 is a hinged double door and is the access door to the Remote Radiator Room 111. This door is 6’x7’. Door D12 is a hinged double door, and is the main entrance door on the downwind side of the building. This door is 8’x10’ with a heat trace.

Doors D1 and D12 act as barriers between the exterior environment and the New Power Plant. Door D11 is a barrier between the Power Generation Room and the Remote Radiator Room.

2.2.3 Interior Specialties / Fixtures

2.2.3.1 Miscellaneous Specialties

2.2.3.1.1 Fire Extinguishers:

In case of a fire in the rooms not covered by the CO_2 fire suppression system, hand held manual fire extinguishers will be used to put out the fire. There are four sets of fire extinguishers in the New Power Plant, making a total of eight.

The fire extinguishers are multi-purpose dry chemical type, suitable for use at temperatures from -65°F to 120°F. All of the fire extinguishers are wall mounted.

The first set of fire extinguishers is located in Hallway 107 across from the Accessory Room. The second set is located at the bottom of the stairs in the Vestibule across from Substation Room. The third set is located on the upwind wall of the Power Generation Room across from the Control Room. The fourth and last set is located on the downwind wall of the Power Generation Room next to the exit door.

All personnel who attempt to use the fire extinguishers in an emergency condition should be trained in their proper use and application.

2.2.3.1.2 Daylighting Tubes:

There are ten Daylight Tubes along the ridge of the Arch over the New Power Plant. The tubes are spaced 20’ apart. Each tube extends 2’ above the steel arch way, and 1.5’ below the steel Archway. These provide additional lighting in the summertime daylight hours. No operational components are included with the daylighting tubes.

2.3 CONVEYING SYSTEMS

2.3.1 Rolling Gantry Hoists

The rolling gantry hoists are used to help maintain the generators in the New Power Plant. The base of the rolling gantry is a Wallace Products Corp. tri-adjust crane or equivalent 10-ton capacity/nominal. It has a 9’6” beam span. It is height adjustable from 10’ to 15’.

Three hoists are associated with the gantry, one electrical and two manual. The electrical hoist has a 5-ton capacity and a 36.5” hook. One of the manual hoists has a 5-ton capacity and a 18” hook. The other manual hoist has a 10-ton capacity and a 36” hook. Two 10-ton capacity adjustable beam clamps can be used with the manual hoist. There is a manual trolley that is compatible with the gantry for use with the manual hoist.

2.4 MECHANICAL SYSTEMS

Primary mechanical systems in the New Power Plant include heat generation and distribution, air ventilation, plumbing, water treatment and storage, fire protection, compressed air, engine/generator set, and control systems.

2.4.1 Heating Generation and Distribution Systems

A total of three heat sources provide primary heat generation to the New Power Plant hydronic heating system. The two primary heat sources are:

- Four (4) skid mounted water jacket heat recovery systems recover heat from the four diesel engine water jackets.
- Four (4) exhaust heat recovery systems recover heat from the four diesel engine exhausts.

Heat required for all connected facilities, including the New Power Plant, is served by one common heating circuit with 6” piping. This is the Main Distribution Loop. The above eight systems deliver heat to the Main Distribution Loop through their respective heat exchangers designated HX 1-4, and EHX 1-4.

The third heat source is:

- A fuel-fired hydronic boiler provides auxiliary heat when needed.

Heat exchangers in the Main Distribution Loop distribute heat to another facility as follows:

Facilities/Heat Exchangers	**Areas Serviced**
New Power Plant	
Heat Exchanger 6	Perimeter heat plus snow melting
Heat Exchangers 7A &B	Water Treatment Facility
Heat Exchangers 10 though 13	Diesel Rapid Start Preheating System
Heat Exchanger 14	Domestic Water System
Other Facilities	
Heat Exchanger 8	Existing New Garage/Shop
Heat Exchanger 9	Existing Power Plant

Main Distribution Loop heat exchangers, areas they service

Heat Exchanger 6 has three pumped heating circuits that distribute the heat required for inside the New Power Plant as well as for snow melting. Two-inch piping serves the heating coils in air handling units (AHU’s) 1 and 2 in the Power Generation Room.

Additional 2” piping serves all other New Power Plant space heating via unit heaters, the cabinet unit heater, finned tube, and the heating coil in AHU-3. Two and one-half inch piping serves the emergency snow melter.

2.4.1.1 Auxiliary Fuel-Fired Boiler

An AN-8 fuel-fired hydronic boiler provides auxiliary heat when needed. The boiler is located in the Power Generation Room adjacent to the Remote Radiator Room. The boiler is a cast iron sectional design using a pressure atomized oil burner. The fire is visible through a hinged flame inspection port.

Normally, the boiler is off. Operation is enabled by the Direct Digital Control (DDC) System when temperature to the load side of Heat Exchanger 5 (return side of the boiler when in emergency interconnect mode) drops to 150°F, and is disabled at 170°F. The DDC System will not enable the boiler until a pump response is established. A DDC System alarm is generated if boiler outlet temperature falls below an adjustable setpoint of 140°F during boiler operation.

A microprocessor-based integrated system specific to the auxiliary boiler controls its systems. Controller memory is non-volatile in order for it to retain data after a power failure. Inputs and outputs include keyboard data entry, 80-character display panel, and self-diagnostics.

The integrated system controls burner operation, boiler warm-up, low and high fire operation, and shutdown. A low water cut-off will prevent boiler operation when boiler water (glycol) falls below a safe level. A high limit temperature control with manual reset for the burner will prevent glycol from exceeding safe system temperatures. The flame is monitored continuously by the DDC System during burner operation.

The auxiliary boiler is fitted with pressure and temperature gauges. A 30-psi boiler relief valve is piped to a 5-gallon bucket to capture any glycol discharge. Forced draft venting penetrates the roof and Arch with a 16” vent stack to an outdoor roof cap. For vent construction details, refer to drawing M9.2, Appendix 4.1.2.

The auxiliary boiler has its own piping circuit and liquid charge. For boiler piping details, refer to drawing M8.1, Appendix 4.1.2. The boiler transfers heat to the Main Distribution Loop through Heat Exchanger 5 using pumps P-10A&B. Heat Exchanger 5 and pumps P-9A&B, P-10&B are located on the waste heat distribution and heat exchanger skid opposite Engine/Generator G-2.

When the Main Distribution Loop is off-line or otherwise not operational, an emergency interconnect can be deployed to heat the New Power Plant. By reversing the position of four manually operated valves, the Auxiliary Boiler is connected directly to the New Power Plant Hydronic Heating System, bypassing the Main Distribution Loop and Heat Exchangers 5 and 6. Changes to the DDC control scheme will be required when doing this.

If a combustion failure occurs, manual reset of the control is necessary. When a safety shutdown occurs, the control will display a message indicating “Lockout” and the reason for the lockout. The manual reset button is located on the face of the Fireye Flame Monitor that is mounted inside the burner control cabinet. The control panel cabinet is mounted on the burner head above the blower motor and fan.

2.4.1.2 Terminal Heat Transfer Units

2.4.1.2.1 Unit Heaters

Typically, unit heaters are ceiling hung. They are copper tubes with aluminum fins, and the tubes are silver brazed to steel headers. Motor-driven propeller-type fans are furnished with fan guards. Among hte controls is a local power disconnect switch.

Hot glycol/water is circulated through the tubes continuously. The DDC System monitors the room temperature. When the sensor calls for heat (user adjustable via the DDC System), the DDC System energizes the fan to deliver heated air to the room. For piping details, refer to drawing M9.2, Appendix 4.1.2.

Room	Designation
Room 102	UH-1
Room 103	UH-2
Room 104	UH-2
Room 106	UH-1
Room 107	UH-2
Room 108	UH-1, UH-3
Room 110	UH-4
Room 111	UH-2

Unit Heater designation, rooms served by unit heaters

2.4.1.2.2 Cabinet Unit Heaters

One cabinet unit heater (CUH-1) is located in the Vestibule. Internal coils are copper tube aluminum fin. A 1” thick throwaway filter is supplied on the inlet side of the squirrel cage centrifugal fan. A manual, multi-speed fan switch is located in the cabinet.

Hot glycol/water circulates through the tubes continuously. The DDC System monitors room temperature. When the room temperature sensor calls for heat (user adjustable), the DDC System energizes the fan to deliver heated air to the room. For piping details, refer to drawing M9.2, Appendix 4.1.2.

2.4.1.2.3 Finned Tube Heaters

One finned tube heater with an enclosure is used in the Restroom. A second finned tube heater without an enclosure is used in the waste holding tank space. These are copper tube, aluminum finned radiators. Access doors are provided to valves.

The DDC System monitors room temperature (user adjustable at DDC Central Workstation). When the room temperature sensor calls for heat, the DDC System energizes the flow control valve to open.

When the valve opens, it allows hot glycol/water to circulate through the tubes, heating the air in the room. No fan is used. For piping details, refer to drawing M9.2, Appendix 4.1.2.

Designation	Room
FT-1 with Enclosure	Room 105 (Restroom)
FT-1 without Enclosure	Waste Holding Area

Finned tube heater designation, space served by finned tube heaters

2.4.1.3 Heating Coils

Air Handling Units (AHU’s) 1, 2, and 3 contain heating coils HC-1, HC-2, and HC-3, respectively. These are copper tube, aluminum finned coils with tubes expanded into cast iron headers. Coils are provided with threaded ports for draining and venting.

Piping to these heating coils includes a self-regulating flow control valve, a bypass balancing valve, and the three-way DDC-controlled flow control valve. Three-way valves modulate heating fluid flow to heating coils in order to maintain the downstream air temperature setpoint.

Refer to *Air Handling Units*, Section 2.4.2.1, for operation details. For piping details, refer to drawing M9.2., Appendix 4.1.2.

2.4.1.4 Heat Exchangers

Heat exchangers are used on the heat collection (generation) side as well as the heat delivery side of the Main Distribution Loop. Heat exchangers provide desirable separation of liquids in piping circuits while allowing heat to be transferred from one (hot) heating fluid to another (cooler) heated fluid. The Exhaust Heat Recovery Silencers (Section 2.4.9.3.2) are gas to liquid heat exchangers. Other heat exchangers are shell and tube or plate and frame construction for liquid to liquid transfer of heat.

The following table lists heat exchangers and pumps that transfer heat from the engine/generator's (G-1 through G-4) jacket water to the Main Distribution Loop. These heat exchangers are all plate and frame construction with nitrile gaskets between stainless steel plates.

The heated liquid (cooler) and the heating (hotter) liquids are pumped on opposite sides of the plates causing the cooler liquid to be heated through the metal plate by the hotter liquid. These heat exchangers perform the same function as a radiator; they allow the heat drawn from the engine's water jacket to be rejected elsewhere.

Engine Generator	Pump(s)	Heat Exchanger
G-1	P-1A and P-1B	HX-1
G-2	P-2A and P-2B	HX-2
G-3	P-3A and P-3B	HX-3
G-4	P-4A and P-4B	HX-4

Heat exchangers and pump designations that transfer heat from the engine/generator jacket water to Main Distribution Loop

A two-way, two-position control valve on the Main Distribution Loop of these heat exchangers normally closes and opens to allow flow through the heat exchanger (refer to Glycol Pumps P-9A & B, *Glycol Pumps*, Section 2.4.1.5) when the engine/generator is operating.

A three-way control valve in the jacket water side of these heat exchangers modulates to maintain a jacket water exiting temperature of 198° F. This is accomplished by diverting flow (refer to Glycol Pumps P-1A & B through P-4A & B, *Glycol Pumps*, Section 2.4.1.5) away from the heat exchanger to the remote radiators as jacket water temperature rises above the setpoint.

If this three-way control valve remains at full open for one minute, the remote radiator fans energize for faster cooling.

The following table lists heat exchangers and pumps that transfer heat from the engine/generator's (G-1 through G-4) hot exhaust to the cooler Main Distribution Loop. Refer to *Heat Recovery Silencers*, Section 2.4.9.3.1, for construction details of these heat exchangers.

Engine Generator	**Pump(s)**	**Heat Exchanger**
G-1	P-5A and P-5B	EHX-1
G-2	P-6A and P-6B	EHX-2
G-3	P-7A and P-7B	EHX-3
G-4	P-8A and P-8B	EHX-4

Heat Exchanger and pump designations that transfer heat from engine/generator hot exhaust to Main Distribution Loop

A three-way liquid flow control valve modulates to pass more or less pumped liquid (refer to Glycol Pumps P-5A & B through P-8A & B, *Glycol Pumps*, Section 2.4.1.5) to maintain a minimum exiting exhaust gas temperature of 350°-375° F. At the same time, it keeps the heated fluid that is exiting at a temperature between 230-235° F.

Any time the Heat Recovery System is off-line, or waste heat is not being used, a bypass valve diverts hot exhaust gas around the heat exchanger to keep fluid temperature at safe levels.

The following table lists the heat exchanger (plate and frame construction) and pumps that transfer heat from the auxiliary boiler to the Main Distribution Loop. Refer to sections *Auxiliary Fuel Fired Boiler*, Section 2.4.1.1, and Glycol Pumps P-10A & B, *Glycol Pumps*, Section 2.4.1.5, for operation details.

Auxiliary Boiler	**Pump(s)**	**Heat Exchanger**
B-1	P-10A and P-10B	HX-5

Auxiliary boiler to Main Distribution Loop pump, heat exchanger

The following table lists heat exchangers (shell and tube construction) and pumps that transfer heat from the Main Distribution Loop to the engine/generator water jacket for "rapid start" engine preheating.

The Rapid Start Engine Preheating pumps are off and the valve is closed when the engine/generator is running. This system keeps the engine/generator warm (when off) and ready for quick starting at any time. A two-way control valve on the Main Distribution Loop supply side (hot inlet) of this heat exchanger modulates to maintain 140°F at the load side return (cold inlet).

Engine Generator	Pump(s)	Heat Exchanger
G-1	P-13	HX-10
G-2	P-14	HX-11
G-3	P-15	HX-12
G-4	P-16	HX-13

Heat Exchangers, pumps that transfer heat for “Rapid Start” engine preheating

Heat Exchanger 6 (plate and frame construction) and the pumps listed in the table below transfer heat from the Main Distribution Loop for New Power Plant heating and snow melting. A two-way control valve on the Main Distribution Loop supply side (hot inlet) of this heat exchanger modulates to maintain 165°F at the return side (hot outlet).

New Power Plant	Pump(s)	Heat Exchanger
Perimeter Heat	P-11A and P-11B	HX-6
Heating Coils	P-12	“
Snow Melter	P-25	“

Heat Exchanger 6 and pumps transfer heat for power plant, snow melting

Heat Exchangers 7A and 7B (plate and frame construction) and existing well water pumps transfer heat from the Main Distribution Loop to well water in the Water Treatment System. Approximately 75% of this well water returns to the Rodriguez Well. It provides heat to maintain the thaw bulb and melt ice to replenish the reservoir. The remaining 25% supplies raw water to the Water Treatment System.

To prevent possible contamination of the water supply by glycol, these heat exchangers have double wall construction with a leak detection vent between the walls. In the event that a leak would occur in either the well water or glycol passages, the leaking fluid would show at the base of the heat exchanger. The control valve modulates to maintain 85° return water temperature to the well.

Heat Exchanger 8 (plate and frame construction) and the existing pumps in the Garage/Shop transfer heat from the Main Distribution Loop to the Garage/Shop hydronic heating system. A two-way control valve on the Main Distribution Loop supply side (hot inlet) of this heat exchanger modulates to maintain 165°F at the Garage Shop return side (cold inlet). In the event of a failure of Auxiliary Boiler B-1, the boilers in the garage shop could act as a backup. Action by the DDC System would be required to accomplish this.

Heat Exchanger 9 (plate and frame construction) and existing pumps in the Existing Power Plant transfer heat from the Main Distribution Loop to the Existing Power Plant Hydronic Heating System. A two-way control valve on the Main Distribution Loop supply side (hot inlet) of this heat exchanger modulates to maintain 165°F at the Existing Power Plant return side (cold inlet).

Heat Exchanger 14 (shell and tube construction) and pumps P-26 and P-27 transfer heat from the Main Distribution Loop to the Domestic Water Recirculation System. To prevent possible contamination of the water supply by glycol, this heat exchanger has a double wall construction with a leak detection vent between the walls. In the event that a leak would occur in either the domestic water or glycol passages, the leaking fluid would show at the base of the heat exchanger. A two-way flow control valve modulates to keep the circulating domestic water temperature high enough to prevent freezing.

Heating Load	**Pump(s)**	**Heat Exchanger**
Water Treatment	Raw Water Pumps	HX-7A & HX-7B
Garage/Shop	Existing Pumps	HX-8
Domestic Water	P-26 & P-27	HX-14

Heat Exchanger 7A, 7B, 8 & 14 designations and associated pumps

2.4.1.5 Glycol Pumps

All pumps with A and B suffixes are paired for lead/lag/alternating operation. One pump acts as the lead pump while the other is on standby. The standby pump alternates to become the lead pump after every normal on/off cycle. A differential pressure switch is piped across each pump to provide pump status to the DDC System central workstation.

If the pump is commanded on, and pump status is not established, an alarm is generated at the DDC System central workstation and the standby pump is energized. Pumps may have variable speed drives to allow the distribution system to match the connected building loads and allow the heat generation system to match the varying engine/generator heat dissipation rates.

Pumps P-1A&B, P-2A&B, P-3A&B, and P-4A&B provide flow to collect waste heat from the engine/generator's (G-1 through G-4) jacket water and deliver it to the Main Distribution Loop. The lead pump runs whenever their connected engine/generator is running. These pumps receive glycol through a suction diffuser. This diffuser contains an inlet strainer and flow straightening vanes to provide non-turbulent flow to the pump suction.

Pumps P-5A&B, P-6A&B, P-7A&B, and P-8A&B provide flow to collect waste heat from the engine/generator (G-1 through G-4) exhaust heat exchangers and deliver it to the Main Distribution Loop. The lead pump runs whenever their connected engine/generator is running.

Pumps P-9A&B provide flow for the Main Distribution Loop and through all heat exchangers connected to the Main Distribution Loop. The DDC System controls the speed of these pumps through variable speed drives (VSD) to maintain differential pressures desired across Heat Exchangers HX-5, HX-8, and HX-9 of 2.7, 10.0, and 10.0 psi, respectively. These pumps receive glycol through a suction diffuser. This diffuser contains an inlet strainer and flow straightening vanes to provide non-turbulent flow to the pump suction.

Pumps P-10A&B provide flow to deliver heated glycol from the B-1 boiler to the Main Distribution Loop by way of Heat Exchanger 5. When the boiler is enabled, the DDC System energizes the lead pump. One pump acts as the lead pump while the other is on standby. The lead pump alternates to the other pump after every normal on/off cycle. A differential pressure switch is piped across each pump to provide pump status to the DDC System. If the pump is commanded on, and pump status is not established, an alarm is generated at the DDC System central workstation and the standby pump is energized. Boiler operation does not occur until pump operation is established. These pumps receive glycol through a suction diffuser. This diffuser contains an inlet strainer and flow straightening vanes to provide non-turbulent flow to the pump suction.

Pumps P-11A&B provide flow to distribute heat from the Main Distribution Loop through Heat Exchanger 6 to heating coils of AHU-1 and 2. These pumps run in a lead/lag/alternating mode. Whenever either AHU is running, the DDC System energized the lead pump. The DDC System alternates the lead pump after every normal on/off cycle. A differential pressure switch is piped across each pump to provide pump status to the DDC System. If the pump is commanded on, and pump operation is not established, an alarm is generated at the DDC System Central Workstation and the standby pump is energized. When both AHU's are running, the DDC System energizes the lag pump.

Pump P-12 provides flow to distribute heat from the Main Distribution Loop through Heat Exchanger 6 to New Power Plant perimeter heating (unit heaters, finned tube heaters) and the heating coil in AHU-3. This pump runs continuously.

Pumps P-13, P-14, P-15, and P-16 provide flow to deliver heat from the Main Distribution Loop to the engine/generator water jacket for “rapid start” engine preheating. These pumps run whenever their connected engine generator is not running.

2.4.1.6 Hydronic Specialties

Because the hydronic systems are closed loop, air separators and expansion tanks are necessary.

2.4.1.6.1 Expansion Tanks

Expansion tanks 1 - 4 are compression type tanks used on jacket water. Expansion tanks 5 - 8 are bladder type expansion tanks. All the tanks accept glycol expansion volume as temperatures increase and replenish the liquid expansion volume in closed systems as the glycol cools off.

Expansion tanks also maintain system pressure. Both types maintain an air volume under pressure. As system glycol heats and expands, this expansion volume enters the tank and displaces (compresses) the air. As system glycol cools and contracts, the compressed air pushes the glycol back into the system, maintaining system pressure. The bladder-type compression tank uses a rubber bladder to separate the air from the liquid so it cannot dissolve in the glycol and lose control of system pressure. Compression tanks have no bladder but are fitted with sight glasses and pressure gauges to visually monitor the compressed air charge.

2.4.1.6.2 Air Separators

Air trapped in a hydronic system can hamper circulation, damage pumps, and cause noise objectionable to occupants. Air separators create a low velocity vortex where air is separated and removed via an automatic air vent from the circulating glycol. Typically, they are located on the suction side of the circulation pump at a high point in the immediate system piping. The tank also provides the make-up water connection for filling needs.

2.4.1.6.3 Flow Controls

Flow controls are valves with brass construction, a union on the inlet, and a temperature/pressure test plug on the inlet. The internal mechanism includes a stainless steel spring operating against a piston or regulator cup to control liquid flow to within 5% of its rated setting.

These valves are self regulating and require no external power or signal. They are used on hot water piping to unit heaters and heating coils where flow needs to be limited to a specific range.

2.4.1.6.4 Balance Valves

Balancing valves are used to balance flow between parallel hydronic circuits sharing the same source circuit and pumps. The balance valves consist of a brass ball valve with ports for measuring differential pressure across the valve seat area. These valves maintain a specific relationship between pressure difference and flow. By measuring the differential pressure port to port, the flow can be determined from a chart or read on a companion meter.

Balancing valves are located on all parallel piping circuits. Typically they are set, paint striped, and locked in position (with a screw) by the test and balance contractor. Once set they will only need changing if the piping circuit is modified to upset the original flow balance.

2.4.1.6.5 Relief Valves

These safety valves are designed, tested, and rated to open and vent pressure in the event of an over pressure condition. They are bronze body construction with teflon seats and stainless steel stem and springs. They are rated by capacity (btu/hr or lb/hr steam), certified, and labeled for the approved usage by the American Society of Mechanical Engineers (ASME).

Relief valves are mounted directly to the vessel protected. The discharge piping size and length is limited according to ASME regulations. Every closed circuit (or circuit that can be closed by changing valve positions) containing a heating and/or pressure source, is required to have a relief valve for over pressure protection. Locations include the air compressor receiver, fuel-fired boiler, shell side of HX-10, wastewater side of HX-5, wastewater side of EXH 1-4, and on the diesel generator hot discharge.

2.4.1.6.6 Glycol Make-up Systems

This complete packaged system includes a solution container and lid, makeup pump and motor, pressure tank with pressure control, low level cut-off and alarm, necessary valves, strainer, reducing valve, and drain.

The glycol makeup system designated as GMS-1 provides glycol/water (60 % glycol and 40% water) makeup to the Auxiliary Boiler Loop, the Main Distribution Loop, the New Power Plant Perimeter Heating Loop and the Emergency Snow Melter Loop.

GMS-2 provides glycol/water (60/40) makeup to all Jacket Water Systems.

Glycol makeup systems are controlled through the DDC System to provide makeup to each hydronic loop individually. Pressure transmitters installed in each hydronic loop sense pressure in their individual system.

The DDC System energizes the glycol makeup pump. A current switch is installed at the makeup pump to provide pump status to the DDC System. If the pump is commanded on and pump operation is not established, an alarm is generated at the DDC Central Workstation. Once pump operation is established, the DDC System will open the specific makeup valve to replenish the affected system. Once the system pressure rises above the set point of the pressure switch, the makeup valve closes and the makeup pump is de-energized.

2.4.1.6.7 Hydronic Meters

Pressure gauges are installed on both sides of system pumps to indicate pump status. All expansion tanks are fitted with pressure gauges or test plugs to check air charge and operating pressure. Pressure gauges are also mounted on all of the glycol makeup pipes. In general, gauges or gauge ports are located adjacent to DDC System pressure sensors. All gauges are protected from constant line pressure by pulsation dampers and tee or lever handle isolation valves. These valves must be opened to make pressure readings; otherwise they are to be closed. Two-inch analogue dials read in both psi and kPa.

Pressure gauge taps or plugs are provided where less frequent readings of pressure or temperature are best taken with a portable gauge that is inserted directly into the fluid. Companion test kits include pressure and temperature gauges with 1/8” diameter “needle type” probes for insertion through a neoprene core similar to a basketball fill valve.

Gauge plugs include a small cap (easy to lose) that should remain on the plug fitting when readings are not being taken.

In general, gauges or gauge ports are located adjacent to DDC System temperature sensors. Thermometers are installed on all heat exchangers. All heat sources, such as the boiler and diesel engine, have thermometers. Stem type and dial thermometers are supplied that read in degrees F and C. Stem type have red appearing mercury indicators. Dial type use a bimetal helix and are filled with silicon fluid to prevent vibration of the needle.

Iron bodied flow meters are located in the wastewater side of Heat Exchangers HX-1, 2, 3, 6, 7A&B, 8 and 9. Bronze bodied flow meters are used in water treatment and for well water at HX-7A&B. These are turbine flow meters with direct read out as well as flow transmitters. The turbine pulse is magnetically transmitted through the case to the register mechanism. A pulse to DC converter is used to output a 4 to 20 ma signal proportional to flow rate measured.

2.4.2 Ventilation Systems

Ventilation air is provided to all spaces within the New Power Plant except the Hallway and Accessory Room #1. The Ventilation System's primary purposes are to replenish air consumed by the diesel engines and provide cooling of the New Power Plant spaces. Space pressurization and air quality are additional requirements.

Outside air (Antarctic air) is ducted up through the floor and is mixed with varying amounts of room air by AHU's. It is then heated, when required, to 40-55° by heating coils inside the AHU's. This cool air is distributed to New Power Plant spaces to control room temperatures (75-85°F) and provide fresh air. The volume of outside air brought into the building is adjusted by inlet air dampers inside the AHU mixing boxes.

2.4.2.1 Air Handling Units

All AHU's have air filters and are fitted with a pressure switch piped across the fan to sense fan operation. AHU's 1, 2, 3, and 4 all have mixing boxes. AHU's 1, 2, and 3 have heating coils. Whenever discharge air temperature or mixed air temperature falls below 36°F, the DDC System will turn the fan off. Whenever the fan is off, the DDC System will close the outside air damper, open the return air damper, and open the heating valve to full flow through the coil. The fan will also be turned off in the event of a fire alarm or if smoke is detected.

AHU's 1 and 2 provide heating, cooling, and makeup air to the Power Generation Room. Each air handler and heating coil is sized for redundant combustion air supplies.

Should one air handler become inoperative, the other is capable of supplying the entire outside air load. Both AHU's 1 and 2 are floor mounted (refer to drawing M4.3, Appendix 4.1.2).

The DDC System controls AHU operation. Two control schemes are under consideration. The primary program will operate both AHU's 1 and 2 continuously and modulate them in unison.

Heating coils HC-1 and HC-2 in AHU-1 and AHU-2 provide heating and cooling. When the room temperature falls below 55°F, the three-way heating valves in both units modulate to maintain a 70°F discharge air temperature to the room. This is the heating mode.

When the room temperature rises above 80°F, the three-way heating valves in both units close and mixed air dampers are modulated to maintain a 40°F discharge air temperature to the room. This is the cooling mode.

When the space temperature is satisfied as determined by the DDC System, the three-way heating valves and the mixed air dampers in both units modulate to maintain a 65°F discharge air temperature to the room. In the event that a differential pressure switch senses that the one AHU fan is not operating, an alarm is generated at the DDC System central workstation. The DDC System will close that AHU's outside air damper, open the return air damper and open the heating valve to full flow through the coil. The mixing air dampers in the other AHU will modulate to maintain room static pressure at .05 inch water column (minimum), with a minimum outside air position of 22% (refer to *Dampers*, Section 2.4.2.10).

A secondary program, as an energy conservation measure, operates in a lead/lag configuration. As the engines, boiler, and exhausts use the air, the lead AHU modulates its outside air damper to maintain room static pressure at .05 inch water column (refer to *Dampers*, Section 2.4.2.10). The lag AHU is energized when the space temperature reaches 85°F and shuts off when space temperature achieves 75°F.

AHU-3 operates as needed to provide ventilation, cooling, and positive pressurization for the Control Room and Accessory Room #2. It is operated by the DDC System for an occupied/unoccupied (user adjustable) time schedule. A wall mounted manual override timer can be set for up to 4 hours of AHU operation.

In the occupied mode, or while on manual override, the unit will run continuously. Initial supply air temperature is set at 65°F. Initial Control Room space temperature is set to 70°F.

When the space temperature rises above 70°F (set point), the heating valve is closed and the outside air damper begins to modulate open. In the occupied mode, the minimum outside air damper position is set for 5% outside air for ventilation.

In the unoccupied mode, the unit is normally off and will cycle on to maintain a maximum Control Room temperature. Initial supply air temperature is set at 55°F. Initial maximum Control Room temperature is set to 80°F. AHU-3 is floor mounted (refer to drawing M4.3, Appendix 4.1.2). Conditioned air volume supplied to Accessory Room #2 is set at 9% of that supplied to the Control Room.

AHU-4 operates as needed to provide ventilation, cooling and positive pressurization for the Substation. It is ceiling mounted, with outside air ducted up to it through the floor (refer to drawing M4.3, Appendix 4.1.2). Relief air from the Substation and Control Room ducts to the Remote Radiator Room. This relief air tempers the Remote Radiator Room. The DDC energizes AHU-4 when the temperature in the Substation reaches 80°F. Initial supply air temperature (set point) is set at 40°F.

AHU-5 runs continuously. It is floor mounted (refer to drawing M4.3, Appendix 4.1.2) and transfers air from the Power Generation Room to other rooms. No outside air dampers or heating coils are needed, since this air transferred has previously been conditioned by AHU’s 1 and 2. Part of this air is distributed to the Fuel Storage Room, where Exhaust Fan #2 is located. The balance is distributed to the Water Treatment Room. A sound attenuator is provided with this unit to minimize noise transmissions from the engine generators (refer to *Soundtraps*, Section 2.4.2.8).

2.4.2.2 Ventilation Fans

One ventilation fan is used in the New Power Plant Building. This fan, designated as VF-1, is a wall mounted fan paired with a fire/smoke damper. It mounts in wall penetration between the Water Treatment Room and the Power Generation Room (refer to drawing M9.1, Appendix 4.1.2). The ventilation fan provides heating to the Water Treatment Room by circulating warmer air from the Power Generation Room. The fan is energized when the Water Treatment Room temperature falls below 55°F and the Power Generation Room exceeds the room temperature in the Water Treatment Room.

A pressure sensor is used to sense air flow. If flow is not established when the fan is commanded “on”, an alarm is generated and reported at the DDC Central Workstation.

2.4.2.3 Exhaust Fans

There are two exhaust fans in the New Power Plant Building to maintain indoor air quality. They both are centrifugal fans that hang from the ceiling. Fan status is monitored for Exhaust Fan #2 by a sail switch. An alarm is generated if flow is not established when the fan is commanded “on”.

Exhaust Fan #1 is located in the Restroom (refer to drawing M9.1, Appendix 4.1.2). Sizing was based on ten air changes per hour. It is switched on with the light by an occupancy sensor. It draws air off the Restroom ceiling and discharges through a backdraft damper and control damper to the outdoors. Its control damper is closed when the fan is not on. Operation of these dampers is critical to prevent freezing in the Restroom.

Exhaust Fan #2 is located in the Fuel Storage Room and runs continuously to keep the room pressure negative with respect to the Hallway (refer to drawing M9.1, Appendix 4.1.2). Half of its exhaust air is drawn from near the floor and the other half from near the ceiling. It discharges through a backdraft damper to the outdoors.

Both exhaust ducts share one common opening in the Arch structure to a common rectangular exhaust hood (refer to drawing M9.1, Appendix 4.1.2).

2.4.2.4 Exhaust Hoods

Two exhaust hoods are used on the New Power Plant. One is a 48” x 48” radiator exhaust air hood located at the downwind bulkhead (refer to drawing M4.3, Appendix 4.1.2).

The other is for exhaust from the Restroom and Fuel Storage exhaust fans. Restroom Exhaust Fan #1 discharges through a 6”diameter insulated duct. Fuel storage Exhaust Fan #2 discharges through a 10”diameter insulated duct. These ducts pass through the Arch structure inside one common 16” x 30” rectangular duct. One common exhaust hood is used. This hood is hinged on one side and bolted on the other (refer to drawing M9.1, Appendix 4.1.2).

2.4.2.5 Outside Air Intake

Outside air flows into the Arch by way of a hood and vertical duct to an opening in the upwind bulkhead (refer to drawing M4.3, Appendix 4.1.2). There are no fans or control devices installed in the Arch outside air opening. Outside air for use in the building is brought in through the floor and ducted to mixing boxes on the individual AHU’s (refer to drawing M9.1, Appendix 4.1.2). Room air is mixed with this incoming Antarctic air and heated when required in the AHU’s.

2.4.2.6 Relief Air Hood

Relief air flows out of the Power Generation Room by way of a 32” x 32” insulated duct and a discharge hood at the downwind bulkhead (refer to drawing M4.3, Appendix 4.1.2). A motorized control damper is located on the Power Generation Relief Air Duct for control.

Relief air exits directly from the Substation and indirectly from the Control Room by an insulated duct to the Remote Radiator Room. Relief air combined with radiator exhaust discharges through a hood at the downwind bulkhead (refer to drawing M4.3, Appendix 4.1.2). This relief air relieves pressure created when outside air is introduced by AHU-3 and AHU-4.

2.4.2.7 Air Outlets and Inlets (Grilles, Registers and Diffusers)

Supply diffusers SA, SB, SC, SD, and SE control air volume, direction, and velocity to optimize comfort, appearance, and noise where conditioning air enters various rooms. Grilles and registers EA, TA, TB, TC, and TD provide security and optimize appearance and noise. Initial design air volume settings and discharge direction are shown on the ventilation floor plan A and B, (refer to drawings M4.1 and M4.2, Appendix 4.1.2). Adjustable volume dampers are supplied when required to adjust airflow for balancing.

2.4.2.8 Soundtraps

One sound attenuator (ST-1) is used on the New Power Plant Building. It’s located in the ductwork from AHU-5 between the Power Generation Room and the Hallway to minimize noise transmission from the engine generators. Engine exhaust heat recovery silencers and engine exhaust bypass silencers are covered in the *Stack Gas* Section 2.4.9.3.

2.4.2.9 Air Cleaning Devices

All AHU’s contain 25-30% dust spot efficient replaceable filter elements. Filter elements are 2” nominal thickness, pleated with cardboard frames. Filter gauges are mounted on the outside of filter housings. The clean filter pressure drop is .22” water gauge at 400 feet per minute face velocity.

2.4.2.10 Dampers

The New Power Plant contains control dampers, volume dampers, backdraft dampers, and fire/smoke dampers. Volume dampers are located where required for system balancing.

These dampers are adjusted and fixed during system test and balance. For damper locations, refer to drawings M4.1 and M4.2, Appendix 4.1.2.

A motorized control damper is located on Power Generation Relief Air Duct. AHU's 1, 2, 3, and 4 have mixing boxes that consist of an outside air damper and return air damper linked together so one opens as the other closes. All mixing boxes have damper operating motors.

Motorized dampers controlled by the DDC System establish room temperature in the Remote Radiator Room. Control dampers are located in the outside air opening, return air opening, and exhaust air opening. The outside air damper is normally closed, the return air damper is normally open, and the exhaust air damper is 5% open (adjustable). When radiator fans start, dampers modulate to maintain a 7°F plenum temperature and .07" water gauge pressure. An alarm is generated if this temperature is not maintained.

Motorized dampers controlled by the DDC System establish room pressure in the Power Generation Room. A motor-operated control damper and counter balanced backdraft damper are located in the relief air ductwork from the Power Generation Room. This control damper is normally closed and modulates open to maintain a maximum space positive pressure of +0.10" water column. AHU-1 and AHU-2 modulate outside air dampers to maintain a minimum positive pressure of +0.05" water column and minimum makeup air of 22%.

Fire dampers are part of the fire protection system. They are provided where ductwork penetrates fire walls, or as required to prevent the spread of fire. They are self-actuated by heat or smoke detectors or by electric operators controlled by the Fire Protection System controls.

2.4.3 Plumbing

The New Power Plant Plumbing Systems and equipment include a Pressure Booster System, sanitary wastewater storage tank, sewer ejector pump, Sewer Tank Sparging System, water closet, urinals, and lavatory equipment. For waste and vent piping details, refer to drawing M6.5, Appendix 4.1.2. For Roof and Arch penetration details for vents, refer to drawings M9.2 and M9.1, Appendix 4.1.2. Heat tape is used on vents to reduce ice buildup at the termination point above the roof.

2.4.3.1 Plumbing Equipment

2.4.3.1.1 Pressure Booster Systems

The water supply distribution is circulated and heat traced for freeze protection. For redundancy and reliability, two circulating pumps (P-26 and P-27) are provided, as well as Heat Exchanger 14.

The lead pump runs continuously. A manual alternator is provided to switch the lead and lag pumps. Experience shows that the circulating pump generates enough heat to maintain desired temperature in the distribution piping. Heat Exchanger 14 is a backup. Refer to drawings M7.1 and M8.4, Appendix 4.1.2, for location and piping details for the Pressure Booster System and Water Treatment System.

The Pressure Booster Skid is located in the Water Treatment Room. The pressure booster skid contains the booster pumps, pressure tank, pipes, valves, manifolds, and control panel all mounted on a steel tubing skid. Booster pumps P-19A and P-19B and a pneumatic pressure tank, T3, maintain water pressure for distribution throughout the complex.

These pumps run in a lead/lag/alternating mode. Whenever system pressure drops below 60 psi, the DDC System energizes the lead pump. Both pumps are off whenever the system pressure is above 75 psi. The DDC System alternates the lead pump after every normal on/off cycle. A differential pressure switch is piped across each pump to provide pump status to the DDC System.

If the pump is commanded on and a pump response is not established, an alarm is generated at the DDC System and the standby is energized. If system pressure drops below 50 psi while the lead pump is operating, the DDC System energizes the lag pump. Both pumps operate together until the system pressure returns to 75 psi.

Booster pump operation is protected by a thermal relief valve to enable running at no flow. Local controls include cut-offs and alarms for low water level and low suction pressure. The local panel door contains an on-off-automatic switch for each pump and indicator lamps for power on and motor overload.

2.4.3.1.2 Sanitary Waste Water Storage Tank

This 800-gallon tank is located below the Restroom floor. It is welded stainless steel construction. Assuming two persons occupy the facility, the tank will require pumping at approximately once every 80 days.

A separate vent system is provided to protect fixture traps during pumping operations. A high level alarm sensor is inside the tank. The DDC System monitors the high level contacts and generates an alarm at the DDC Central Workstation.

2.4.3.1.3 Sewage Ejector Pump

A tank-mounted ejector pump, P-18, pumps out the waste storage tank. The stored waste is pumped to a tanker truck through a Kam-lok connection located in the utility access chase at the downwind end of the Arch. An additional connection is located under the stairs at the Restroom. Controls consist of a manual switch, a separate mercury float switch high level alarm, and alarm bell.

2.4.3.1.4 Sewer Tank Sparging System

A compressed air sparging system injects air into the waste water storage tank for a six-minute period out of every hour. This is to prevent the waste from becoming anaerobic and prevent solidification of the waste during the storage period. The air diffuser nozzle is located 2” above the bottom of the waste water storage tank. Compressed air is piped to it through a ball valve, strainer, pressure regulator, and sparging control valve located behind and above the Restroom door. Sparging cycle and duration timing can be set on the face of the control valve assembly.

2.4.3.2 Plumbing Fixtures

The plumbing fixtures are designed for low water consumption. The water closet (P-1), urinal (P-2), and lavatory (P-3) all discharge to the waste water storage tank (T-4) located below the restroom floor.

2.4.3.2.1 Water Closet

The water closet (toilet) is vitreous china, floor mounted with a bottom outlet. It uses a push button flushing valve, water pressure-assisted flush and uses 1.6 gallons of water per flush.

2.4.3.2.2 Urinal

The urinal is wall hung fiberglass construction. It is a waterless unit with integral trap assembly and low density trap fluid. It discharges to the waste water storage tank below.

There is no water connection. A plastic trap insert in the bottom of the urinal contains eight ounces of trap liquid. This liquid has a specific gravity less than urine (the liquid floats on top). The heavier urine penetrates the trap liquid and flows into the drain.

2.4.3.2.3 Lavatory

The lavatory basin (sink) is wall hung, vitreous china construction. It is fitted with a push button single water temperature supply fitting and water economy aerator (.5 gpm restricter). Drain connection includes an open grid strainer, brass P-trap, and clean-out plug.

2.4.4 Water Treatment, Storage and Distribution

Raw water is pumped from the existing Rodriguez Well to the Water Treatment Room of the New Power Plant Building. It is treated to neutralize corrosivity, filtered to remove any particulate, and disinfected. The rate of flow pumped from the well is approximately 17 gallons per minute, of which 13 is heated by HX-7A&B to 85°F and returned to provide heat to maintain the thaw bulb and melt ice to replenish the reservoir. Four gallons per minute is drawn off of the return loop for treatment, storage, and distribution.

Treatment consists of the addition of sodium bicarbonate (baking soda) for alkalinity adjustment. The water then passes through a 5-micron filter followed by a carbon filter for taste, odor adjustment, and suspended lead particle removal. Disinfection is accomplished with calcium hypochlorite. Contact time is provided in the chlorine contact chamber. The water is then stored in two 3,000-gallon storage tanks.

2.4.4.1 Chemical Solution Tanks and Pump Assemblies

Chemical solution tanks are 35-gallon, high density, polyethylene construction with graduations on the side. Each tank contains an electric motor-driven flange-mounted agitator for mixing chemical solutions for injection.

Injection pumps P-20, P-21, and P-22, are positive displacement with integral flow meters to pace the chemical addition. A dial on the pump allows the operator to adjust the rate manually. Half-inch suction tubing draws solution off the bottom of the tanks through a strainer and foot valve (check valve) to each pump.

Pumps discharge into the 1” raw water line through an injection check/back pressure valve. Interconnecting tubing is polyethylene with compression connections. Three of these assemblies are used for injection of hypochlorite, sodium bicarbonate, and one for alternate chemical solutions or as a backup.

2.4.4.2 Chlorine Contact Chamber

The chlorine contact chamber is a 12” diameter 24’ long serpentine pipe constructed of high density polyethylene (HDPE) (refer to drawing M9.5, Appendix 4.1.2).

The purpose of the chlorine contact chamber is to slow freshly treated water flow for a 30-minute residence time. This time provides proper dispersion of chemicals for treatment and disinfection. It is located downstream of chemical treatment tanks and static mixers, and upstream of treated water storage tanks.

2.4.4.3 Static Mixers

In-line static mixers are located downstream of chemical solution tanks to assure chemicals evenly disburse throughout the raw water flow.

2.4.4.4 Treated Water Storage Tanks

The two 3,000-gallon tanks (T-1 and T-2) are calculated to be one day's water supply for summer periods, and three day's supply for winter periods. They are welded stainless steel construction with removable lids. For construction details, refer to drawing M9.5, Appendix 4.1.2.

Each tank has a fill control valve controlled by a mechanical float. This keeps the water level nearly constant. A high level float switch and alarm is used for overflow protection. To warn of possible overflow, an alarm generates at the DDC Central Workstation.

2.4.4.5 Limestone Contactor

Limestone contactors consist of a 30" diameter x 60" tall stainless steel tanks filled with 1" limestone chips. A steel distributor located at the bottom of the tank assures even flow and equal exposure of the influent water to the 1" limestone chips (refer to drawing M9.5, Appendix 4.1.2).

Raw water is pumped from the existing Rodriguez Well to the Water Treatment Room of the New Power Plant Building where it passes through three limestone contactors for pH adjustment. The rate of flow pumped from the well is approximately 17 gallons per minute. All 17 gallons flow through the limestone contactors. Approximately 13 gallons return to the well.

2.4.4.6 Chlorine Analyzer

Chlorine level is monitored on the treated water. Chlorine residuals are maintained at 0.2 mg/liter (.2 PPM).

The chlorine analyzer requires carbon dioxide as the buffer solution. A cylinder of carbon dioxide is connected to the analyzer through a pressure regulator and flow meter.

The chlorine analyzer receives a sample of treated water taken from downstream of the pressure boost system through a needle valve and pressure reducing valve. The sample is analyzed and discharged into storage tank T-1 or T-2. For details, refer to drawing M9.5, Appendix 4.1.2.

2.4.4.7 pH/ORP, Flow, Temperature, and Pressure Monitors/Transmitters

Chlorine, pH, flow, temperature, and pressure within the Water Treatment System are monitored continuously. Monitoring devices are located directly to the monitored piping with local LED displays and push button calibration. All monitors contain analogue (4 to 20 mA) transmitters for communication of measurements to the local displays and to the DDC Central Workstation.

pH is monitored on the raw water and on the treated water. pH levels are maintained between 7.0 and 8.0.

Flow transducers are located upstream of chemical injection and downstream of the Pressure Boost System. Temperature transducers are located upstream of chemical injection and downstream of the Pressure Boost System. Pressure transducers are located upstream of chemical injection, upstream and downstream of carbon filters and limestone contactors and downstream of the Pressure Boost System.

2.4.4.8 Filters

The two filters in the Water Treatment System are designated F-1 and F-2.

F-1 is a 5-micron sediment filter. It has a replaceable cartridge of cellulose fiber and a built-in shut off valve.

F-2 is an activated carbon filter. It has a replaceable cartridge. The cartridge contains 5-micron cellulose fiber, a depth bed of activated carbon, and siliphos crystals. A post filter retains carbon particles from leaving the depth bed.

2.4.5 Fire Protection System

Fire protection coverage is provided for the Fuel Storage Room and for each of four engine/generators. It is activated automatically by multiple (at least two) detectors. The DDC System shuts off the fuel supply, the fans, and closes the dampers to the effected area. The Fire Protection System discharges carbon dioxide to extinguish the fire by opening automatic valves on carbon dioxide (CO_2) cylinders.

Emergency manual release is also provided at the cylinder banks. A pre-discharge alarm signal allows occupants to evacuate the facility.

The DDC System monitors the fire alarm system zone contacts and generates an alarm at the central workstation if any of the contacts close.

2.4.5.1 Carbon Dioxide Extinguishing System

Pressurized cylinders of liquid CO_2, valves, and distribution lines are used to discharge agent through nozzles in the zone(s) where fire is detected. Since CO_2 is an asphyxiant, all personnel must be instructed to evacuate the area at the first alarm and to not re-enter the space, including the Arch area, unless equipped with a Self-Contained Breathing Apparatus (SCBA) (see *Breathing Air System*, Section 2.4.7).

2.4.5.1.1 Storage Cylinders

100-pound capacity CO_2 cylinders are provided. Cylinders have liquid level sensors and pressure indicators. The primary cylinder bank is located in the Substation. In the event of a discharge, replacement cylinders are stored in the Cargo facility.

2.4.5.1.2 Manual Stations

Manual pull stations are located at cylinder storage locations. Each station is labeled as to which area is protected by that station. The control lever is double acting with a “push in” tab and a “pull down” lever which locks into position after releasing a spring-loaded contact switch. When pulled, the fire alarm sounds and a signal is sent to the DDC System.

2.4.5.1.3 Discharge Nozzles

Discharge nozzles control the rate of discharge and distribute extinguishing agent (CO_2) uniformly throughout the protected area. Typically, they are located 6” below the ceiling.

2.4.5.1.4 Zone Valves/Control Heads

Each cylinder bank of CO_2 cylinders has a cylinder control valve. This valve has an integral safety valve, and it can operate automatically or manually. Check valves are used at the connection to the header pipe to prevent back flow. For details, refer to drawing M11.1, Appendix 4.1.2.

2.4.6 Compressed Air System

Compressed air is piped as needed throughout the New Power Plant. The compressor and receiver are located in the Power Generation Room.

Air outlet accessories include a 40-micron filter, a pressure regulator with external pressure gauge, and a system lubricator with automatic drain. The lubricator can be filled while under pressure. For air outlet piping details, refer to drawing M9.2, Appendix 4.1.2.

The DDC System monitors the run status of the air compressor. The DDC System also monitors the air system pressure. If the system pressure falls below 80 psi (adjustable), an alarm generates at the DDC System central air handler.

2.4.6.1 Air Compressor/Receiver

A two-stage reciprocating compressor is used mounted on top of a vertical 80-gallon receiver tank (refer to drawing M6.5, Appendix 4.1.2). Provisions for V-belt adjustment are on the base plate.

Safety controls include a manual reset, low oil pressure cutout. The 2-horse-power, three-phase motor has electronic overheat protection on each leg. The normal pressure switch cut-off pressure is 175 psig and cut-on pressure is 90 psig. The receiver tank has a safety valve, pressure gauge, drain cock, and an automatic float-actuated condensate trap.

2.4.7 Breathing Air System

2.4.7.1 Breathing Air Compressor

The Bauer Breathing Air Compressor System is located in the Accessory Room #2 in the New Power Plant. The compressor system is used to fill Self-Contained Breathing Apparatus (SCBA) bottles. It consists of a 10-HP compressor, a freestanding fill station for the SCBA bottles, and 3 banks of 4 storage cylinders. The system is rated for 5000 psi at 10,000 ft. elevation.

The fill station can fill 3 SCBA bottles at a time. The SCBA bottles are utilized by fire fighting and emergency personnel to access contaminated air spaces.

2.4.8 In-Plant Fuel Oil System

Fuel is delivered to two fuel storage day tanks located in the Fuel Room for bulk fuel storage. Currently this fuel comes from the existing Garage Shop. In the future, fuel will come from a New Fuel Storage and Transfer Pump Module.

From the day tanks, fuel is transferred to the four engine/generators and auxiliary boiler through five individual fuel suction lines, and returned through a common return pipe. The supply and return piping runs in a floor raceway between channel members and below removable steel grating for protection.

2.4.8.1 Fuel Meters

Fuel meters are located on the central supply line to the day tanks. Duplex meters are on supply and return lines to the Auxiliary Boiler and each Engine/ Generator 1-4 (refer to drawing M8.5, Appendix 4.1.2). They are supplied with special seals for pumping fuel as cold as -60°F. The meters are positive displacement rotary type, requiring no external power, with a connection to the DDC System.

2.4.8.2 Fuel Storage Day Tanks

Two 1000-gallon fuel storage day tanks (T-5 and T-6), located in the Fuel Storage Room, are sized for a total of 24 hours of fuel consumption. They are welded steel construction, horizontal cylinders with steel support saddles. Each tank has a fill port, level gauge, vent, outlet connections, and a high level alarm. The DDC System controls the fuel solenoid valves to maintain the level of fuel in the fuel storage tanks.

2.4.8.3 Fuel Oil Filters

Raycor 75/1000FGX duplex water separator/fuel filters with 2 micron filter elements are supplied with the diesel/generators.

2.4.9 Engine-Generator Set/Engine Systems

Three of the engine/generator sets in the New Power Plant are Caterpillar Model 3512B. A fourth engine/generator set is planned for future growth. The following is a list of Caterpillar and accompanying equipment that support this engine/generator set.

Caterpillar 3512B--1015 EKW 60 Hertz -- Packaged Engine/Generator Set
Diesel Engine 3512B, Prime (varying load to 80%, unlimited hr/yr)
SR4 Power Generator
Lake Shore Automatic Paralleling Switchgear
Engine Mounted Electronic Instrument Panel
Electric Power Generation Switchgear Conversion
Generator Set Load Sensor and Load Sharing Module

Caterpillar and accompanying equipment that support this engine/generator set

Woodward Load Sharing Speed Control
Programmable Relay Control Module(PRCM)
Relay Driver Module
Relay Board
CCM (for communication with host computer)
Digital Voltage Regulator
24 VDC Prelube Pump
Fuel Priming Pump
24 VDC 35 Amp Battery Charging Alternator
24 VDC Dual Electric Starters
Dual Jacket Water Heaters, 240/480 VAC, 1 PH
24 Volt Batteries and Mounting Rack
Charles Industries Battery Charger
Nelson EcoVent Recirculator (Crankcase Breather)
Bell and Gossett “U” Series Heat Exchangers and Pumps (Preheat)

Caterpillar and accompanying equipment that support this engine/generator set

2.4.9.1 Diesel Engines and Accessories

2.4.9.1.1 Diesel Engine

The diesel engines were selected to optimize fuel and energy generation characteristics. The base load engine produces 1025 kW at sea level and 797 kW at the South Pole Station, regardless of the fuel type. These engines are turbocharged V-12, rated to burn AN-8 fuel at 12,000 feet elevation. The engines have electronic unit injectors. They are equipped with jacket water cooling of compressed combustion air from the turbocharger (after cooling).

This engine has a “Prime” duty rating. The prime rating allows for a varying load, for an unlimited number of hours per year. The normal load factor is up to 80%, for an unlimited number of hours per year.

A 100% load is only allowed for 5% of the operating cycle. Engine specifics are covered on one of the following Caterpillar publications.

Operation and Maintenance Manual	SEBU6916-02
Systems Operation Testing and Adjusting	SEBU6916-02
Specifications	SENR6562-01
Troubleshooting	SENR1003-03
Disassembly and Assembly	SENR6564-01

Engine Specifications and their corresponding Caterpillar publication

2.4.9.1.2 Engine Speed Governing System

The Generator Set Load Sensor is used to establish load sharing for paralleled generator applications. This Generator Set Load Sensor is used with Woodward speed control governors (see Caterpillar Service Manual SENR6565-01). It measures the generator kilowatt load with current and potential transformers. It outputs an analog voltage signal which biases the speed reference of the engine speed control governor. The engine speed control governor affects the actual fuel level setting and precisely maintains its proportional share of system load while maintaining a fixed frequency. These items are located within the Lake Shore Switchgear and Caterpillar Switchgear Conversion equipment.

2.4.9.1.3 Engine Protective Devices

The Caterpillar Electronic Control Module (ECM) detects and initiates engine shutdown when a measured parameter reaches factory programmed trip points. A display on the engine-mounted panel will display a fault code for system diagnostics.

The following table contains the common alarms and their factory programed trip-point values or condition. Additional programmed alarms can be added.

Low Engine System Voltage	Below 20 VDC
Engine Overspeed	1.18 times synchronous speed
Overcrank	Crank cycle timed out
Not in AUTO	Engine Control Switch
Low Oil Pressure @ Turbocharger	Limit Varies with RPM
Low Engine Oil Pressure	Limit Varies with RPM
High Coolant Temperature	Above 102° C (215 °F)
Low Coolant Temperature	Below 80° C (176 °F)
Low Coolant Level	Level sensor is tripped
Low Fuel Level	Level sensor is tripped

Common alarms and factory programmed trip-point values

The action alarm provides the operator with an audible indication of abnormal engine operation. Action alarms visually display on the Caterpillar Main Display Module. The Alarm Silence Switch will silence the action alarm for five minutes. The alarm will sound again if the condition has not been corrected. The Lake Shore Switchgear panels also have warning lights and a rotating beacon for alarms. Engines are also shut down by fire protection heat sensors located over the engines.

2.4.9.2 Cooling System

Diesel engines require cooling of cylinder heads, cylinder walls, turbo charger bearings, pistons, and piston rings through the oil intercooler and engine water jacket. High temperatures can cause damaging metal distortion and breakdown of materials and lubricants.

Diesel engine cooling is accomplished by circulating jacket water (glycol) through the external jacket water heat rejection loop. This loop consists of duplex electric motor driven circulation pumps (see Glycol Pumps P-1A&B through P-4A&B, *Glycol Pumps*, Section 2.4.1.5), waste heat recovery heat exchangers (see Heat Exchangers HX 1 - 4, *Heat Exchangers*, Section 2.4.1.4), remote air cooled radiators (see Remote Radiators RR-1 through RR-4, *Remote Radiators*, Section 2.4.9.2.2), fluid expansion provisions (see Expansion Tanks ET-1 through ET-4, *Expansion Tanks*, Section 2.4.1.6.1), glycol make-up provisions (see Glycol Make-up Systems GMS-1 and GMS-2, *Glycol Make-up Systems*, Section 2.4.1.6.6) and interconnecting piping and control valves.

2.4.9.2.1 Jacket Water

Jacket water is a mixture of 60% antifreeze (glycol) and 40% water for freeze protection to -60°F. When the engine/generator is operating, controls are set to maintain the temperature of water leaving the jacket at 198°F. The maximum allowable exiting jacket water temperature, for safe engine operation, is 210°F. When the engine/generator is not operating, the “Rapid Start” Heating System maintains jacket water temperature at 140°F.

2.4.9.2.2 Remote Radiators

Remote radiators (RR-1, RR-2, RR-3 and RR-4) are located within an insulated plenum, which is normally kept at approximately 7°F to maximize heat transfer efficiency. Dampers allow for controlled air recirculation (refer to *Dampers*, Section 2.4.2.10) within the plenum to limit exposure of radiator components to extreme cold temperatures. Operation is on an as needed basis.

Remote radiators are used for engine/generator cooling any time the heat recovery system is off-line, or the waste heat is not being used for any reason.

When engine/generator exiting jacket water temperatures exceed 198°F and the control valves remain at full open, the remote radiator fans start. The DDC System controls the speed of the remote radiator fans in order to keep jacket water (glycol) temperatures at safe levels.

2.4.9.3 Stack Gas

Exhaust gas from engine generators can be routed either to heat recovery silencers or non-heat recovery silencers by exhaust bypass valves. The exhaust bypass valve consists of two butterfly valves in a tee section linked together to one operator controlled by the DDC System. When glycol heat recovery exiting temperatures exceed 230°F, or anytime the heat recovery system is offline, exhaust gas bypasses heat recovery silencers and is directed to non-heat recovery silencers.

Heat recovery silencers are designated EHX-1, EHX-2, EHX-3, and EHX-4, and are located in the Power Generation Room. Non-heat recovery silencers are designated S-1, S-2, S-3, and S-4, and are located in the utility chase above the building roof, but inside the Arch.

2.4.9.3.1 Non-Heat Recovery Silencers

Besides providing a bypass for the heat recovery silencers, non-heat recovery silencers provide containment and noise reduction. Under full load, the diesel exhaust can exceed 1000°F. When waste water temperatures approach 230°F exiting the heat recovery silencers, the exhaust bypass valve diverts exhaust flow to these silencers. For piping details, refer to drawing M7.3, Appendix 4.1.2.

2.4.9.3.2 Heat Recovery Silencers

Exhaust heat recovery silencers remove heat from the hot exhaust gas directly to the glycol of the Main Distribution Loop (refer to *Heating Generation and Distribution Systems*, Section 2.4.1). They are of single-pass U-tube construction.

The hot gas passes through the outer shell and the glycol through the inside of the U-tube piping. Tubes have .75” tall fins welded to the outside diameter to enhance the gas side heat transfer. High temperature exhaust heats the fins and U-tube piping on the outside, causing the cooler glycol/water mixture pumped (refer To Glycol Pumps P-5A&B through P-8A&B, *Glycol Pumps*, Section 2.4.1.5) through the inside to get hot. Tube bundles are removable for access to the inside and outside of the tubes.

For typical interconnection piping of heat recovery silencers and exhaust bypass valve details, refer to M7.2, Appendix 4.1.2.

2.4.9.4 Lubricating Oil System

A standard configuration engine/generator set typically requires oil changes every 500 hours. One standard oil change for the Caterpillar Model 3512B is 88 gallons of oil. The primary purpose for the Lubricating Oil System is to use less oil by extending the required time between oil changes. The diesel engines for the New Power Plant have larger oil sump capacities of 171 gallons and will continuously reprocess the lubricating oil to extend its life to 8000 hours between oil changes. Oil is pumped and reprocessed, one diesel engine at a time, to limit cross contamination. Each engine has its own supply pipe and a common return to and from the engine lubrication oil reprocessing skid. Lubricating oil is manually sampled and tested for metal content every 250 hours of operation.

2.4.9.4.1 Lubricating Oil Filters

Duplex oil filters are supplied as part of the Caterpillar diesel engine. Filter elements should be changed before the filter gauge indicates 15 psi.

2.4.9.4.2 Lube Oil Reprocessing Module

This system is self-contained, skid mounted, and located in the Power Generation Room. This unit is capable of manual override, switch over, and startup to enable use of the feed pump for oil changes (drain and fill) and switch over from generator to generator.

It contains a centrifuge (for removal of solids from the lube oil), an oil feed pump, an 8-gallon effluent tank, and programmable control panel. This module controls all lube oil processing functions. It automatically senses and switches over to the current online generator and it operates continuously with manual shutdowns for cleaning and maintenance.

2.4.9.5 Engine Fuel Oil System

2.4.9.5.1 Fuel Oil Filters

Raycor 75/000FGX duplex oil filters are supplied with 2020 series 2-micron (brown) filter elements. The double filter manifold has shut off valves for filter element replacement. Filter gauge typically reads 3.7 psi clean and 15 psi maximum for a dirty filter. The lower bowl collects water and heavy particles separated by the integral turbine centrifuge.

2.4.10 Control Systems

There are two major control systems in the New Power Plant, plus other smaller systems. The two major systems are the DDC System and the CMS (Control and Monitoring System). The CMS is described in the Electrical section and is intended to primarily monitor and control the power generation aspects of the facility. There is also an FDAS (Fire Detection and Alarm System) which is interconnected to the DDC System.

Critical aspects of the building operation are monitored from the DDC System, but that only alarms and status are monitored from the engine generators and made available from the Power Generation Systems for DDC display.

2.4.10.1 Direct Digital Control and Monitoring Equipment

All safety shutdowns are hard wired and are not dependent on the DDC System to operate.

The New Power Plant DDC System consists of one central workstation (PC) and nine local control panels. A central workstation exists at both the New Power Plant and at the Garage/Shop. System Architecture is arranged so that each control panel used can continue its operation independently of communication or network with other panels or if central control is lost. A few control parameters are transmitted over the network. These have programmed default values for times that the network may be down.

All points (system status inputs) are programmed at the host computer and graphics are displayed to show the location and system where that point resides. The following is a list of the local panels (TCP 1-9) and the building system components they monitor or control.

TCP-1
Main Distribution Loop
Controls On/Off of Pumps P-9A and P-9B Monitors Pumps P-9A and P-9B On/off Monitors Status of P-9A and P-9B Controls speed (VSD) of Pumps P-9A and P-9B

Local Panel TCP-1 and building system components it monitors

Monitors These Conditions at Heat Exchanger HX-5 1. Waste Heat Supply Temperature @ HX-5 2. Waste Heat Return Temperature @HX-5 3. Waste Heat Flow Through HX-5 4. Waste Heat Inlet/Outlet Differential Pressure 5. Waste Heat Pump Discharge Pressure 6. Boiler Water Supply Temperature @ HX-5 7. Boiler Water Return Temperature @ HX-5
Controls On/off of Pump P-10A and P-10B Monitors Status of Pump P-10A and P-10B Controls On/off of Pump P-11A and P-11Bs Monitors Status of Pump P-11A and P-11B Controls On/off of Pump P-12 Monitors Status of Pump P-12
Monitors These Conditions at Heat Exchanger HX-6 1. Waste Heat Supply Temperature @ HX-6 2. Waste Heat Return Temperature @ HX-6 3. Waste Heat Flow Through HX-6 4. Waste Heat Inlet/Outlet Differential Pressure 5. Glycol Heat Supply Temperature @ HX-6 6. Glycol Heat Return Temperature @ HX-6 7. Command to Waste Heat Control Valve 8. Monitor Position of Waste Heat Control Valve

Local Panel TCP-1 and building system components it monitors

TCP-2
Glycol Make-up System #1 (GMS-1) Controls On/off of Pump P-17 Monitors Status of P-17
Monitors Pump Discharge Pressure Monitors Pressure Switch #1 Controls Open/Close of Valve #1 Monitors Pressure Switch #2 Controls Open/Close of Valve #2 Monitors Pressure Switch #3 Controls Open/Close of Valve #3 Monitors Pressure Switch #4 Controls Open/Close of Valve #4 Monitors Low Level Glycol Alarm Switch GMS-1
Glycol Make-up System #2(GMS-2) Controls On/off of Pump P-18 Monitors Status of P-18

Local Panel TCP-2 and building system components it monitors

Monitors Pump Discharge Pressure Monitors Pressure Switch #1 Controls Open/Close of Valve #1 Monitors Pressure Switch #2 Controls Open/Close of Valve #2 Monitors Pressure Switch #3 Controls Open/Close of Valve #3 Monitors Pressure Switch #4 Controls Open/Close of Valve #4 Monitors Low Level Glycol Alarm Switch GMS-2
Fuel Storage System Controls Open/Close for Fill Valve to T-5 Monitors Fuel Storage Tank T-5 Level High/Low Controls Open/Close for Fill Valve to T-6 Monitors Fuel Storage Tank T-6 Level High/Low
Waste Storage Tank T-4 High Level Alarm
Fire Alarm Status Monitors Fire Alarm Zone #1 Monitors Fire Alarm Zone #2 Monitors Fire Alarm Zone #3 Monitors Fire Alarm Zone #4 Monitors Fire Alarm Zone #5
Station Air Compressor (AC-1) Monitors Run Status Monitor Air System Delivery Pressure

Local Panel TCP-2 and building system components it monitors

TCP-3
Air Handling Unit 1 (AHU-1) Monitors Power Generation Room Temperature Controls On/off of AHU-1 Fan Monitors Status of AHU-1 Fan Controls and Monitors Position of Mixing Box Dampers Monitors Air Temperature Upstream of Heating Coil Low Temperature Alarm Upstream of Heating Coil Controls Position of Heating Coil Heating Control Valve Monitors Position of Heating Coil Heating Control Valve Monitor Air Temperature Delivered to the Space Monitors Carbon Dioxide Detector In Discharge Ductwork Building Pressure Values are Shared by TCP-8 and TCP-3
Air Handling Unit 2 (AHU-2) (Same as AHU-1)

Local Panel TCP-3 and building system components it monitors

Air Handling Unit 3 (AHU-3) (Same as AHU-1 plus manual override timer)
Air Handling Unit 4 (AHU-4) Same as AHU-1, (Less Heating Control Valve Interfaces and less the mixed air temperature sensor)
Air Handling Unit 5 (AHU-5) Controls On/Off of AHU-5 Fan Monitors Status if AHU-5 Fan
Ventilation Fan VF-1 Monitors Water Treatment Room Temperature Controls On/Off of VF-1 Fan Monitors Status of VF-1 Fan
Exhaust Fan EF-2, Control On/Off of Fan
Substation Unit Heater UH-1 Monitors Substation Room Temperature Controls On/Off of UH-1 Fan
Hallway Unit Heater UH-2 Monitors Hallway Room Temperature Controls On/Off of UH-2 Fan
Fuel Storage Unit Heater UH-3 Monitors Fuel Storage Room Temperature Controls On/Off of UH-3 Fan
Control Room Unit Heater UH-1 Monitors Control Room Temperature Controls On/Off of UH-1 Fan
Facility Air Compressor (AC-1) Status Facility Air Compressor, Air Pressure

Local Panel TCP-3 and building system components it monitors

TCP-4
Rapid Start Jacket Water System Generator G-1 Status Jacket Water Return Temperature Controls On/Off of Pump P-13 Monitor Status of Pump P-13 Controls Position of Heating Control Valve Monitors Position of Heating Control Valve

Local Panel TCP-4 and building system components it monitors

Jacket Water Heat Recovery System Controls Stop Only of Engine/Generator G-1 Controls On/Off of Pump P-1A Monitors Status of Pump P-1A Controls On/Off of Pump P-1B Monitors Status of Pump P-1B Controls Open/Closed of Waste Heat Control Valve to HX-1 Monitors Waste Heat Flow Through HX-1 Monitors Waste Heat Inlet Temperature at HX-1 Monitors Waste Heat Outlet Temperature at HX-1 Monitors Jacket Heat Inlet Temperature at HX-1 Monitors Jacket Heat Outlet Temperature at HX-1 Controls Position of Jacket Water Control Valve to HX-1 or RR-1 Monitors Position of Jacket Water Control Valve to HX-1 or RR-1 Monitors Jacket Water Leaving Temperature at G-1 Controls On/Off of Remote Radiator Fan Monitors Status of Remote Radiator RR-1 Fan Controls Speed (VSD) of Remote Radiator RR-1 Fan Monitors Jacket Water Temperature Leaving Remote Radiator RR-1 Monitors Jacket Water Temperature Returning to G-1
Engine Exhaust Heat Recovery Controls On/Off of Pump P-5A Monitors Status of Pump P-5A Controls On/Off of Pump P-5B Monitors Status of Pump P-5B Monitors Exhaust Gas Temperature Leaving G-1 Monitors Exhaust Gas Temperature Leaving EXH-1 Monitors Waste Heat Temperature Leaving EXH-1 Monitors Waste Heat Temperature Entering EXH-1 Controls Position Of Waste Heat Flow Control Valve to EXH-1 Monitors Position Of Waste Heat Flow Control Valve to EXH-1 Controls Position Of Exhaust Gas Bypass Valve Monitors Exhaust Gas Pressure at G-1

Local Panel TCP-4 and building system components it monitors

TCP-5
Rapid Start Jacket Water System Generator G-2 Status Jacket Water Return Temperature Controls On/Off of Pump P-14 Monitors Status of Pump P-14 Controls Position of Heating Control Valve Monitors Position of Heating Control Valve
Jacket Water Heat Recovery System Controls Stop Only of Engine/Generator G-2 Controls On/Off of Pump P-2A Monitors Status of Pump P-2A Controls On/Off of Pump P-2B Monitors Status of Pump P-2B Controls Open/Closed of Waste Heat Control Valve to HX-2 Monitors Waste Heat Flow Through HX-2 Monitors Waste Heat Inlet Temperature at HX-2 Monitors Waste Heat Outlet Temperature at HX-2 Monitors Jacket Heat Inlet Temperature at HX-2 Monitors Jacket Heat Outlet Temperature at HX-2 Controls Position of Jacket Water Control Valve to HX-2 or RR-2 Monitors Position of Jacket Water Control Valve to HX-2 or RR-2 Monitors Jacket Water Leaving Temperature at G-2 Controls On/Off of Remote Radiator Fan Monitors Status of Remote Radiator RR-2 Fan Controls Speed (VSD) of Remote Radiator RR-2 Fan Monitors Jacket Water Temperature Leaving Remote Radiator RR-2 Monitors Jacket Water Temperature Returning to G-2
Engine Exhaust Heat Recovery Controls On/Off of Pump P-6A Monitors Status of Pump P-6A Controls On/Off of Pump P-6B Monitors Status of Pump P-6B Monitors Exhaust Gas Temperature Leaving G-2 Monitors Exhaust Gas Temperature Leaving EXH-2 Monitors Waste Heat Temperature Leaving EXH-2 Monitors Waste Heat Temperature Entering EXH-2 Controls Position Of Waste Heat Flow Control Valve to EXH-2 Monitors Position Of Waste Heat Flow Control Valve to EXH-2 Controls Position Of Exhaust Gas Bypass Valve Monitors Exhaust Gas Pressure at G-2

Local Panel TCP-5 and building system components it monitors

TCP-6
Rapid Start Jacket Water System Generator G-3 Status Jacket Water Return Temperature Controls On/Off of Pump P-15 Monitors Status of Pump P-15 Controls Position of Heating Control Valve Monitors Position of Heating Control Valve
Jacket Water Heat Recovery System Controls Stop Only of Engine/Generator G-3 Controls On/Off of Pump P-3A Monitors Status of Pump P-3A Controls On/Off of Pump P-3B Monitors Status of Pump P-3B Controls Open/Closed of Waste Heat Control Valve to HX-3 Monitors Waste Heat Flow Through HX-3 Monitors Waste Heat Inlet Temperatureat HX-3 Monitors Waste Heat Outlet Temperature at HX-3 Monitors Jacket Heat Inlet Temperature at HX-3 Monitors Jacket Heat Outlet Temperature at HX-3 Controls Position of Jacket Water Control Valve to HX-3 or RR-3 Monitors Position of Jacket Water Control Valve to HX-3 or RR-3 Monitors Jacket Water Leaving Temperature at G-3 Controls On/Off of Remote Radiator Fan Monitors Status of Remote Radiator RR-3 Fan Controls Speed (VSD) of Remote Radiator RR-3 Fan Monitors Jacket Water Temperature Leaving Remote Radiator RR-3 Monitors Jacket Water Temperature Returning to G-3
Engine Exhaust Heat Recovery Controls On/Off of Pump P-7A Monitors Status of Pump P-7A Controls On/Off of Pump P-7B Monitors Status of Pump P-7B Monitors Exhaust Gas Temperature Leaving G-3 Monitors Exhaust Gas Temperature Leaving EXH-3 Monitors Waste Heat Temperature Leaving EXH-3 Monitors Waste Heat Temperature Entering EXH-3 Controls Position Of Waste Heat Flow Control Valve to EXH-3 Monitors Position Of Waste Heat Flow Control Valve to EXH-3 Controls Position Of Exhaust Gas Bypass Valve Monitors Exhaust Gas Pressure at G-3

Local Panel TCP-6 and building system components it monitors

TCP-7
Rapid Start Jacket Water System Generator G-4 Status Jacket Water Return Temperature Controls On/Off of Pump P-16 Monitor Status of Pump P-16 Controls Position of Heating Control Valve Monitors Position of Heating Control Valve
Jacket Water Heat Recovery System Controls Stop Only of Engine/Generator G-4 Control On/Off of Pump P-4A Monitor Status of Pump P-4A Control On/Off of Pump P-4B Monitor Status of Pump P-4B Control Open/Closed of Waste Heat Control Valve to HX-4 Monitors Waste Heat Flow Through HX-4 Monitors Waste Heat Inlet Temperature at HX-4 Monitors Waste Heat Outlet Temperature at HX-4 Monitors Jacket Heat Inlet Temperature at HX-4 Monitors Jacket Heat Outlet Temperature at HX-4 Controls Position of Jacket Water Control Valve to HX-4 or RR-4 Monitors Position of Jacket Water Control Valve to HX-4 or RR-4 Monitors Jacket Water Leaving Temperature at G-4 Controls On/Off of Remote Radiator Fan Monitors Status of Remote Radiator RR-4 Fan Controls Speed (VSD) of Remote Radiator RR-4 Fan Monitor Jacket Water Temperature Leaving Remote Radiator RR-4 Monitor Jacket Water Temperature Returning to G-4
Note: Space is Provided in TCP-7 for Future Engine Exhaust Heat Recovery

Local Panel TCP-7 and building system components it monitors

TCP-8
Remote Radiator Plenum System Monitors Remote Radiator Plenum Temperature Monitors Remote Radiator Plenum Pressure Monitors New Power Plant Building Pressure Note: Building Pressure Values are Shared by TCP-8 and TCP-3

Local Panel TCP-8 and building system components it monitors

Controls Position of Outside Air Damper Monitors Position of Outside Air Damper Controls Position of Return Air Damper Monitors Position of Return Air Damper Controls Position of Exhaust (relief air) Air Damper Monitors Position of Exhaust (relief air) Air Damper
Power Generation Room Unit Heater UH-4 Monitors Power Generation Room Temperature Controls On/Off of UH-4 Fan (North) Controls On/Off of UH-4 Fan (South)
Remote Radiator Room Unit Heater UH-2 Monitors Remote Radiator Room Temperature Controls On/Off of UH-2 Fan
Monitors Waste Heat Return Temperature at EHX-1 Control Valve **Monitors Waste Heat Return Temperature at EXH-2 Control Valve** **Monitors Waste Heat Return Temperature at EXH-3 Control Valve**
Boiler B-1 Controls Enabling Signal to Boiler B-1 Monitors Boiler B-1 Supply Temperature Monitors Boiler B-1 Return Temperature Monitors Boiler B-1 Low Fire Status Monitors Boiler B-1 High Fire Status
Note: Waste Heat Temperature at Heat Exchanger 5 from TCP-1 must be transmitted to TXP-8 for Boiler enabling

Local Panel TCP-8 and building system components it monitors

TCP-9
Water Treatment System
Monitors HX-7A Waste Heat Supply Temperature Monitors HX-7A Waste Heat Return Temperature Monitors HX-7A Well Water Supply Temperature Monitors HX-7A Well Water Return Temperature Monitors HX-7A Well Water Flow Controls, Monitors Position of Waste Water Heating Control Valve Monitors Well Water Ph, Pre-Limestone Contactor Monitors Well Water Ph, Post Limestone Contactor Monitors HX-7B Waste Heat Supply Temperature Monitors HX-7B Waste Heat Return Temperature

Monitors HX-7B Well Water Supply Temperature Monitors HX-7B Well Water Return Temperature Monitors HX-7B Well Water Flow Controls Position of Waste Water Heating Control Valve Monitors Position of Waste Water Heating Control Valve Monitors Total Waste Heat Flow to Water Treatment System for HX-7A, HX-7B and HX-14 Monitors Water Treatment Control Alarm
Monitors Status of Pump P-20 Monitors Status of Pump P-21 Monitors Status of Pump P-22 Monitors Ph, Post Chemical Treatment Monitors Water Storage Tank T-1 Level Monitors Water Storage Tank T-2 Level Monitors Status of Pump P-19A Monitors Status of Pump P-19B Monitors Chlorine Monitor Monitors Treated Water Flow Monitors Water System Pressure Monitors Domestic Water Supply Temperature Monitors Domestic Water Return Temperature Controls Position of Heating Control Valve at HX-14 Monitors Position of Heating Control Valve at HX-14
Vestibule Room 101 Cabinet Unit Heater CUH-1 Monitors Vestibule Temperature Controls On/Off of CUH-1 Fan
Water Treatment Room 102 Unit Heater UH-1 Monitors Water Treatment Room Temperature Controls On/Off of Unit Heater UH-1 Fan
Accessory Room #1 Room 103, Unit Heater UH-2 Monitors Accessory Room #1 Temperature Controls On/Off of Unit Heater UH-2 Fan
Accessory Room #2 Room 104. Unit Heater UH-2 Monitors Accessory Room #2 Temperature Controls On/Off of Unit Heater UH-2 Fan
Restroom, Room 105, Finned Tube Radiator FT-1A Monitors Restroom Temperature Controls Open/Close of Heating Control Valve FT-1A Monitors Control Valve Position at FT-1A
Waste Holding Area, Finned Tube Radiator FT-1B Monitors Waste Holding Area Space Temperature Controls Open/Close of Heating Control Valve FT-1A Monitors Control Valve Position at FT-1B

Local Panel TCP-9 and building system components it monitors

2.4.10.1.1 Control Valves

All control valves have position indicators, local manual overrides at the valve, and spring return for fail-safe operation (i.e., will fail in a safe position in the event of freeze, fire, power failure, or temperature protection).

2.4.10.1.2 Damper Operators

All damper operators have position indicators at the damper and are spring return for fail-safe operation (i.e., will fail in a safe position in the event of freeze, fire, power failure, or temperature protection). For damper function information refer to *Dampers*, Section 2.4.2.10.

2.4.10.1.3 Input/Output Sensors

Fan operation is sensed by using a differential pressure switch. Pump operation is sensed by using a differential pressure switch. Electric motor operation is sensed by using a current sensing relay with current transformers. Damper and valve positions are sensed by using potentiometers mounted on the operator or crank arm.

Temperature sensors are generally Resistance Temperature Devices (RTD). They are used for outside air temperature, mixed air temperature, supply and return air temperature, and hot water and glycol temperature. For measuring fluids in piping or tanks, a well is used. For measuring air temperatures, averaging type sensors are used to represent temperatures of a cross section.

Analog level sensors measure differential pressure in liquids and transmit a proportional electrical signal to the DDC System.

Specialized sensors are used to detect and measure levels of oxygen and CO_2.

2.4.10.1.4 Transmitters

CO_2 monitors located in the HVAC ductwork transmit voltage or current outputs proportional to CO_2 levels detected. They are capable of measuring 0 to 2000 PPM (parts per million) of CO_2.

Fuel Storage Tanks are supplied with level transmitters. Variable Frequency Drives (VFD's) transmit motor speed signals. pH transmitters are used for well water and at the limestone contactors. There is a chlorine transmitter in the Water Treatment System.

Differential pressure transmitters are located at HX-5, HX-6, between the Power Generation Room and outside, and between the Remote Radiator Room and the discharge plenum. The transmitters at heat exchangers send out a 4 to 20 ma signal proportional a 0 to 20 psi difference between the heat exchanger inlet and outlet connections.

Differential pressure transmitters at pumps P-9A& P-9B transmit a 0 to 20 ma signal proportional to a 3.5 - 200” water column. This pressure difference signal is used to determine the flow rate in the Main Distribution Loop.

Pressure transmitters are located in the glycol make-up systems, the air compressor, the Domestic Water Boost System and the Engine Exhaust System. Pressure transmitters for glycol make-up systems are field adjustable for 0 to 25, 0 to 50 or 0 to 100 psi. They measure the system pressure at each glycol make-up pump. They transmit a 4 to 20 ma signal proportional to the pressure range.

Temperature transmitters are located throughout the New Power Plant. They convert low-level RTD outputs to a standard current (4 to 20 ma) signals for transmission. Some temperature probes are long averaging types. Some are bendable to traverse ductwork.

Iron-bodied flow meters are located in the waste water side of Heat Exchangers HX-1, 2, 3, 6, 7A&B, 8 and 9. Bronze-bodied flow meters are used in Water Treatment and for well water at HX-7A&B. These are turbine flow meters with direct read outs as well as flow transmitters. The turbine pulse is magnetically transmitted through the case to the register mechanism. A pulse to DC converter is used to output a 4 to 20 ma signal proportional to flow rate measured.

2.5 ELECTRICAL SYSTEMS

2.5.1 Interior Distribution System

2.5.1.1 Panelboards

Panelboards function as the smallest unit of the Power Distribution System. Power arrives to the panelboard via a main circuit breaker or main lug and is then distributed to individual smaller loads via properly sized branch circuit breakers installed within the panelboard.

All panelboards are Square D type NQOD installed with bolt-on breakers. Panel O-103HA is a 277/480 Volt (V), 3-phase, 4-wire, 42-space panelboard. Panelboard O-103HA is normally powered from PMDE Circuit #2. In the event of a catastrophic failure, the panel will be fed from RMDE Circuit #2.

All other panelboards are 120/208 V, 3-phase, 4-wire. Panel O-103LA is fed from panel O-103HA via a 150 kVA step-down 480 V:120/208-V wye, 3-phase transformer. In turn, O-103LA feeds panels O-103LB, O-103LC, and O-103UPS.

2.5.1.2 Motor Control Centers

A Motor Control Center (MCC) is similar to a panelboard in that it provides a central location for the distribution of power. However, MCC's generally feed larger loads, typically motor loads.

Two MCC's are installed in the Power Generation Room. MCCA is fed from either the PMDE Circuit #5 or RMDE Circuit #5, with a 200 Amp trip. MCCB is fed from either the PMDE Circuit #6 or RMDE Circuit #6, with a 200 Amp trip. Both MCC's have 480 V, 3-phase, 4-wire, 2000 Amp rated bus.

Automatic magnetic controllers with coil operating voltages of 120V/60 hertz (Hz) are provided for 0-3 horsepower (HP) motors. Motor controllers are energized via a momentary or maintained signal to the control circuit (by DDC control, external contacts or integral Hand-Off-Auto (HOA) switch), which then provides AC power to the coil pulling in the armature of the contact block. Full voltage is provided to the motor.

In the event of a motor overload, or a single phase condition, integral thermal magnetic overloads will shut down the operation of any motor supplied by the motor controller. Once the overload condition has been resolved and cleared, the motor controller may be reset and normal operation may resume.

Automatic softstart controllers with coil operating voltages of 120V/60 Hz are provided for motors of 5-HP and larger. Softstart motor controllers are energized in the same fashion as magnetic motor controllers. However, softstart motor controllers provide different starting and stopping characteristics. The softstart controllers provide field adjustable voltage ramp and current limit settings. Additionally, they provide freewheel or voltage ramp stopping settings. In the event of motor overload, solid-state thermal overload provides protection and has a manual reset.

VFD's are provided for motors whose associated equipment requires variation in speed to maintain system parameters. Variable speed frequency control is solid-state, microprocessor-based and is accomplished through a diode bridge rectifier and pulse width modulation. The system includes protection and annunciation features including but not limited to:

- Current limit to automatically prevent overcurrent trip on all phases due to momentary overload conditions.
- Instantaneous overcurrent, undervoltage, overvoltage trips.
- Ground fault protection.
- Power, motor temperature, voltage/current state indication.
- Acceleration/deceleration rate adjustment.

Sensors, devices, and wiring in conjunction with the DDC System provide a 4-20 mA and/or 0-10 VDC input signal to initiate and maintain the required speed control for the associated equipment.

For equipment schedules, compartment orientation, and applicable controller-types, refer to Motor Control Center shop drawings, Appendix 4.2.4.1.2.

2.5.1.3 Uninterruptible Power Supply

The Uninterruptible Power Supply (UPS) is manufactured by Liebert. It utilizes a single-phase, 208 V feed from panel O-103LA and provides single-phase 208 V feed to panel O-103UPS.

Under normal operating conditions, the UPS provides continuous conditioned AC power to the load. During normal operation, the output of the UPS inverter is used. Input AC power is converted to DC by the rectifier/charger. The DC power charges the UPS battery and provides input power for the inverter. The inverter converts DC power to conditioned AC power which supplies the critical load. If input power is interrupted, the battery will immediately supply DC power required by the inverter to maintain continuous AC power to the load.

The UPS can carry up to a 15 kVA load for over 20 minutes (longer at reduced load) utilizing sealed lead acid batteries. The static bypass line provides an alternate power path during an overload condition or UPS fault. The maintenance bypass line is a hard-wired line through the UPS, which supplies the critical load with unconditioned power when switched to this position.

A Simple Network Management Protocol (SNMP) kit is bundled with the UPS. This hardware and software package allows communication and control of the UPS through an Ethernet network.

2.5.1.4 Enclosed Motor Controllers and Contactors

Motor controllers and contactors provide a means either locally or remotely, of starting and stopping of motors. Local controls consist of HOA switches mounted on the enclosure face. Remote control will be determined by DDC logic or user input at the DDC Central Workstation. For additional motor controller information, refer to *Motor Control Centers*, Section 2.5.1.2.

2.5.1.5 Enclosed Disconnect Switches

Disconnect switches provide a local means of disconnecting power from the connected loads. Disconnect switches are installed per National Fire Protection Agency (NFPA) Article 70, (also known as National Electrical Code, NEC). All disconnect switches are manufactured by Square D and are properly sized for the load. As a general rule, non-fused disconnect switches are utilized.

2.5.2 Power Generation and Distribution

All primary power generated at the South Pole originates in the New Power Plant.

Three primary power Caterpillar 3512B Diesel Generators (DG's) are installed in the Power Generation Room. A similar, but smaller, fourth DG is provided for operation as a peak shaving unit. The primary DG's generate 480 V wye power, and are rated for 750 kW at 0.8 pf (power factor) at Station elevation.

Closing to a dead bus:

1) start a generator,
2) bring it up to the correct voltage and frequency,
3) close the appropriate generator switchboard (GC 1-4)
4) close the molded case switch at the Generator Control Master (GC-M),
5) close the preferred main distribution equipment (PMDE) feeder distribution breaker or the redundant distribution equipment (RMDE) feeder distribution breaker,
6) close distribution breakers in PMDE per standard operating procedure.

Closing to a hot bus (in manual mode):

1) molded case switch in GC-M open,
2) start a generator,
3) bring it to the correct voltage and frequency,
4) synchronize the generator to GC-M bus,
5) close the molded case switch at the GC-M,
6) transfer load to the desired generator using generator load sharing controls,
7) open molded case circuit breaker of other generator,
8) shut down secondary generator per manufacturer procedures (refer to Caterpillar Publication SEBU6916-02).

After a catastrophic failure at the PMDE or tripped breaker:

1) identify and remove source(s) of fault,
2) open the PMDE breaker in the GC-M,
3) open all distribution breakers in the PMDE,
4) open all distribution breakers in the RMDE,
5) if required, start an engine, bring it up to speed,
6) if required, close the molded case switch at the GC-M,
7) close the RMDE breaker in the GC-M,
8) close distribution breakers in RMDE per standard operating procedure.

2.5.2.1 Unit Substation

The Unit Substation is installed in the Substation Room. It consists of a dry-type, medium voltage transformer with three distribution switches. The transformer has 480/277 V electrostatically-shielded primary windings and 4160 V secondary windings, and is rated for 500 kVA, 3-phase, at 60 Hz.

It is fed from either PMDE Circuit Breaker #9 or RMDE Circuit Breaker #9. The three switches are on the secondary side of the transformer, and consist of 5 kV, 3-pole disconnects with 80E fuses. The switch frames are rated for 200 Amps. The Unit Substation provides 4160 V electrical power to the Dark Sector Labs. 4160 V is utilized to reduce voltage-drop due to the significant distance to the Dark Sector area.

2.5.2.2 Distribution Switchboards

The four generators are directly connected to the GC-1 through GC-4 switchboards, respectively. GC-1 through GC-3 contain 3-pole, 1200 Amp molded case switches. GC-4 is a 3-pole, 500 Amp molded case switch.

The generators are then tied to the GC-M through 3-pole, 1200 Amp motor-operated switches that are connected to the synchronizing bus.

The GC-M is a 277/480 V, 3-phase, 4-wire system with a 2000 Amp copper insulated synchronizing bus. The GC-M feeds both the Preferred Main Distribution Equipment (PMDE) and the Redundant Main Distribution Equipment (RMDE) through interlocked 2000 Amp molded case switches. Through a mechanical interlock installed on the unit, either the PMDE feeder switch or the RMDE feeder switch must be open before the other can be closed.

In normal operation, all power flow will be through the PMDE. Both the PMDE and RMDE utilize 277/480 V, 3-phase, 4-wire systems with 2000 Amp copper insulated bus.

The Emergency Power Plant is connected to the GC-M through a 3-pole, 200 Amp breaker. The breaker is manufactured to close to the bus only if the bus is de-energized. For additional details, refer to drawings E11.1 and E11.5, Appendix 4.1.2.

The GC-M, PMDE, and RMDE function to protect the generators and the feeder conductors in the event of overload or fault conditions. Individual circuit breakers will open based on designer-selected parameters.

2.5.2.3 Automatic Paralleling Switchgear

The GC-M contains the Programmable Logic Controllers (PLC's), which contain the program logic for the automatic operation of the generators and switchgear. It provides the controls, sensors, instrumentation, motorized circuit breakers, and synchronizing bus to facilitate automatic paralleling of the engine/generators.

To set the load demand operation, the operator should:

1) Close the Isolation Switches MCS1, MCS2, MCS3, MCS4 (all).
2) Close one of the load breakers, PMDE or RMDE. Only one load breaker may be closed at a time. Locking the Kirk Key Lock on one breaker will release the key, allowing the other breaker to be unlocked and closed.
3) Select the generator sequence using the Generator Sequence Selector Switches (GSS) 1-4 in the GC-M. This sequence determines which generator will be the Lead Generator with the remaining generators as Standby Generators. Placing a GSS in the 4th position will make that unit the Peaking Generator.

Placing all the Generator Control Switches (CS) in the GC-1, 2, and 3 in the Auto position will start the Lead Generator. Once the Lead Generator has attained proper voltage, frequency, and synchronized to the bus, its circuit breaker will close to the load bus.

The PLC will continuously monitor the load level of the bus. If the load is within 80% of the capacity of the generating unit online for 2 minutes, it will automatically start the Peaking Engine Generator Set, synchronize, and close to the bus.

Under control of the Load Sharing Module (LSM), the generator will assume its proportional share of the load. Once the load falls below 70% of the generating capacity of the units on the bus for 15 minutes, the Peaking Generator will be removed and placed into cooldown after which time its operation will be terminated.

If the Peaking Generator has a fault at any time during its operation, its breaker will open and the engine will be shut down. The generator in Sequence 2 will be signaled to start and parallel with the load bus.

Two generators will continue to operate in parallel until the operator intervenes by turning off the generator in the Sequence 2 position.

Note: If the load increases to 100% of the generating capacity of the unit on line, the Peaking unit will be signaled to start and parallel immediately.

During automatic operation, the operator should:

1) Close the Isolation Switches MCS1, MCS2, MCS3, MCS4 (all).
2) Close one of the load breakers, PMDE or RMDE. Only one load breaker may be closed at a time. Locking the Kirk Key Lock on one breaker will release the key, allowing the other breaker to be unlocked and closed.
3) Select the generator sequence using the GSS 1-4.
4) Place all CS into the Auto position.
5) The Lead Engine Generator will be signaled to start. The unit will attain proper speed and voltage and then close to the load bus.
6) The Peaking Engine Generator set will be automatically synchronized to the bus when called for by the load demand program. Upon proper synchronization, its circuit breaker will be signaled to close.
7) The engine generator sets will share load under control of the LSM.

8) If the Lead Engine Generator set develops a trouble condition, the next engine generator set in the sequence will automatically start and be placed online, providing the CS is in the Auto position.
9) The electrical system may be remotely monitored by connecting a computer to the RS486 to RS232 converter in the GC-M.

To set the operation manually, the operator should:

1) Place the Control Switch into the Manual position. The circuit breaker will not automatically close in this position.

Placing the switch into the Manual position will automatically start the engine generator set and the generator's voltage and frequency should attain its proper operating level of 480 V and 60 Hz. If necessary the voltage and frequency may be adjusted to the above levels by using the Voltage Adjust Rheostat (VAR) and, or the Speed Adjust Potentiometer (SAP) respectively.

2) Close the Isolation Switches MCS1, MCS2, MCS3, MCS4 (all).
3) Close one of the load breakers, PMDE or RMDE. Only one load breaker may be closed at a time. Locking the Kirk Key Lock on one breaker will release the key, allowing the other breaker to be unlocked and closed.
4) Select the generator sequence using the GSS into the On position.
5) Compare the incoming generator's voltage and frequency (Digital Meters) with the bus voltage and frequency (Analog Meters) and adjust the generator to match the bus, if necessary.
6) When the synchronize lights are dark and the synchroscope indicates that the generator is synchronized, turn the Breaker Control Switch (BCS) to the Closed position. The circuit breaker will close to the load bus.

Note: In the Manual position, the Sync Check Relay and the Automatic Synchronizer prevent the circuit breaker from closing unless the generator is synchronized to the emergency bus; however, they will not actively synchronize the generator to the load bus. When they are synchronized, it closes a set of contacts which arms the Breaker Control Switch.

7) Remove the load from the generator by reversing the above procedure and turning the circuit breaker switch to the Open position. Allow the engine to run in the unloaded condition to simulate a cool-down cycle.
8) Turn the Control Switch to the Off/Reset position to terminate engine's operation.

The generator sequence may be changed at any time during normal operation by placing another unit in the Lead (1) position while the current Lead Generator is running. The incoming generator will start and parallel with the current Lead Generator. When the incoming generator has closed to the load bus, the original Lead Generator's sequence may be changed to any other sequence position which will cause its breaker to open and it to shut down after a cooldown period.

2.5.2.4 Power Conditioning Equipment

Power conditioning equipment consists of transient voltage surge suppression (TVSS) and UPS. The TVSS is an Advanced Protection Technologies, Inc. model XTE/4XHP, 277/480 V, 3-phase, 4-wire.

The TVSS is a modular parallel suppressor designed for downstream installation panelboard application. It has a multi-stage suppression circuit consisting of field proven, fast acting, matched 40mm motor operated valves (MOV's). A redundant surge suppression path is provided for each mode, guaranteeing continuous service and exceptionally long mean time between failures.

Each surge suppression module is individually fused for severe over-voltage swells and for high fault currents, ensuring safe operation.

A filter network is added to provide wave shape smoothing and a high level of EMI/RFI noise attenuation (up to -50dB from 100kHz to 100MHz). Online diagnostics continuously monitor the unit status and feature redundant LEDs to signal a reduction in surge capacity or loss of a suppression circuit. An audible alarm with test and silence features is included in the standard diagnostic package.

For UPS information, refer to Section 2.5.1.3.

2.5.2.5 Dry-type Transformers

Dry-type transformers are utilized at the station because oil-type transformers may freeze and because of the increased maintenance required for the oil-type. The low voltage transformer is O-103TA, which resides in the Substation Room. It is fed from panel O-103HA and feeds panel O-103LA. It is a 480 V: 208/120, 150 kVA, 3-phase, 60 Hz with an electrostatic shield. For additional details on the transformers, refer to drawings E11.5 and E9.1, Appendix 4.1.2.

2.5.3 Lighting

2.5.3.1 Site Lighting

The exterior of the New Power Plant is illuminated by gasketed, enclosed incandescent fixtures located throughout the building. The fixtures use 130 V lamps.

Site lighting is controlled and operated by surface mounted weatherproof switches (located on the building exterior adjacent to the Vestibule doors) and in conjunction with the Arch lighting control contactors (located in Substation). The switches, when switched to the “on” position, energizes the lighting contactor coils through a control relay, which closes the line/load contacts and illuminates the associated lighting fixture loads.

Use of exterior lighting must be coordinated through the station Facility Engineer.

2.5.3.2 Interior Luminaries

All lighting is powered from panel O-103HA in Substation. Interior lights consist of both incandescent and fluorescent fixtures. Incandescent fixtures are found in the Remote Radiator Room. The incandescent fixtures are gasketed, enclosed fixtures using 130 V lamps (refer to drawing E3.1 and 3.2, Appendix 4.1.2).

All fluorescent fixtures are 4’ x 1’, pendant-mounted, 2- or 3-lamp luminaires using 277V magnetic ballasts. A ballast is a device that is used to start a lamp and maintain proper current and voltage to keep it operating. Fluorescent and High-Intensity Discharge (HID) lamps require ballasts. All lamps are F32, T-8 (for more details, refer to drawing E1.1, Appendix 4.1.2).

Nineteen light fixtures in the hallway and Power Generation Room are permanently wired “on”. These lights are located to provide minimum exit lighting in the event that all other lights in those spaces are off.

All interior lighting is controlled by lighting switches and/or occupancy sensors. In designated areas, lighting is controlled by occupancy sensors which provide power to the lighting fixtures when someone enters the room. During the periods when the room is unoccupied, the lighting fixture remain off. Manual override is provided in the event or sensor failure.

2.5.3.3 Emergency Lighting Units

Emergency lights are installed per Uniform Building Code (UBC) requirements to provide egress lighting in the event of loss of power to interior or exterior emergency light fixtures. The interior emergency lights consist of two 12-Watt PAR 36 lamps and a lead calcium battery that will provide constant light output for 90 minutes in the event of power failure.

The remote head emergency lighting fixtures in the Arch use batteries that are located in the building and provide 90-minute constant light output similar to the interior emergency lighting fixtures. The emergency lights are connected to the same 277 V branch circuits as the other lights in the space.

2.5.3.4 Exit Lighting/Signs

Exit lighting/signs utilizing fluorescent lamps with DC lamp back-up are utilized in the building exit fixtures. An exit light is located on the east wall of Power Generation Room above the door. Two exit lights are located in Hallway 107 leading to the exit on the west side of the building. The exit fixtures are 277 V and have an integral lead calcium battery backup in the event of a power failure. Two F5TT lamps are standard.

Self-luminous exit signs are used in the Arch areas. The self-luminous units do not have an electrical connection and operate continually through a tritium / phosphorus reaction.

2.5.4 Engine-Generator Set/Generator Systems

2.5.4.1 Engine-Generator Set Controls

2.5.4.1.1 Engine Control Panel

Caterpillar 3512B Packaged Engine/Generator Sets are operated through an Electronic Instrument Panel (refer to Caterpillar Service Manual SENR6587-01, Section 4.2.4.5.1.1, Volume XIV). This engine mounted panel is the control information center for the engine system.

It houses the four instrument modules, the engine control switch (ECS), the emergency stop push button, instrument module control switches, action alarm switch, electronic service tool interfaces connector and the customer interface connectors.

Switch Position 1 “On/Off Reset”
Removes power from the engine
Switch Position 2 “Auto”
Enables switching from remote controls
Switch Position 3 “Manual/Start”
Begins the cycle to start the engine and allows the engine to run
Switch Position 4 “Cooldown/Stop”
Commence cooldown the terminates fuel injection to stop the engine

Engine Control Switch on the electronic instrument panel

Manual Start Crank Switch (MANCS)
Allows the operator to crank the engine regardless of other controls
Overspeed Verify Switch (OSS)
Allows the operator to test overspeed protection system
High/Low Idle Switch (LIS)
Allows the operator to hold the engine at low idle position
Prelube Override Switch (PLOS)
Allows the operator to override the prelube pump sequence

Internal Switches inside the Electronic Instrument Panel

The Main Display Module receives information from the switches, sensors and other electronic controls on the engine using the CAT data link. The main display module processes this information and outputs it to its own LCD, the three gauge clusters, and/or the action alarm. These components show the operator the condition of engine systems and system diagnostic information.

Main Display Module
Six digit readout LCD (liquid crystal display), Codes
Five flashing LEDs (light emitting diodes) alarm indicator lights
Gauge Cluster Module (Standby)
Engine oil pressure, kPa (psi)
Engine coolant temperature, ° C (° F)
Battery/Charging system voltage, VDC
Engine fuel pressure, kPa (psi)
Gauge Cluster Module (Prime)
Right hand and left hand exhaust temperatures, ° C (° F)

Display and Gauge Modules on the Electronic Instrument Panel

Right hand and left hand air inlet restriction, ° C (° F)
Fuel filter restriction, kPa (psi)
Oil filter restriction, kPa (psi)
Gauge Cluster Module (Premium)
Inlet air pressure (boost), kPa (psi)
After coolant temperature, ° C (° F)
Inlet air temperature, Aftercooler Water Temp. plus 30° C is Max.
Engine oil temperature, 107 °C (225° F) is recommended maximum
Pyrometer

Display and Gauge Modules on the Electronic Instrument Panel

The Programmable Relay Control Module is a means of adding relay outputs, alarms, and fault indicators to the engine/generator set controls (refer to Caterpillar Service Manual SENR6588-02, Appendix 4.2.4.5.1.5, Appendix XIV).

The engine/generator receives information via a Caterpillar data link from the Engine Control Module (ECM). The ECM is programmed using its keypad and displays on its two liquid crystal displays. It outputs to accompanying Relay Driver Modules. This enables the connection of horns, lamps or additional relays.

The Pyrometer is connected to twelve Type K thermocouples. These thermocouples measure exhaust temperatures at the inlet to the turbocharger. These exhaust temperatures are good indicators of engine performance and valve temperatures. These temperatures should be monitored frequently, and as often as hourly during critical load conditions. The normal operating temperature limit is 650°C (1200°F). The extreme operating temperature limit (where severe engine damage may result) is 718°C (1325°F).

2.5.4.1.2 Generator Control Panel

Refer to *Automatic Paralleling Switchgear*, Section 2.5.2.3.

2.5.4.1.3 Generator Control/Start Batteries

The generator control/start battery is a Caterpillar 9X-9720 12 V low antimony calcium design in a polypropylene case. It has 275-minute reserve capacity, and can deliver 140 Amp-hour capacity after 20 hours charging.

2.5.4.1.4 Control/Start Battery Charger

The control/start battery charger is a Charles Industry's AA2420 with fully automatic equalizing and diagnostic alarms. This charger has a DC ammeter, DC voltmeter, equalize light, AC On light, low and high voltage light, equalize test button, AC circuit breaker, terminal board, low/high voltage alarm relays, and a 304 stainless steel enclosure. The battery input requires 108-132 V, 60Hz, and it outputs 20 Amps, at 24 VDC. Physically, it is 16.307" x 15" x 8.5", and weighs 38 pounds. The battery requires an operating temperature of 32°F to 122°F, and has convection cooling.

This charger offers three methods of equalizing: float/equalize switch, 0-24 hour timer, and 0-24 automatic equalize time. The charger offers fully automatic equalizing, diagnostic alarms, battery temperature compensation, stainless steel for corrosion resistance, vacuum impregnated, ferroresonant transformer, and flush meters.

If battery voltage drops below a set value, i.e. 25.5 VDC, the charger is switched to the equalize mode and the yellow equalize light illuminates. The charger remains in equalize mode until the battery voltage reaches another set value (for instance, 28 VDC). This ensures that the battery is completely recharged and not cycled. At this voltage, the charger switches to the float mode and the equalize light extinguishes.

A red low-voltage alarm lights if the battery voltage remains low. A red high-voltage alarm lights if battery voltage remains high. For remote locations, an optional summary alarm relay is available.

The charging system permits adjustments to the low and high voltage setpoints based on manufacturers' recommendations. Precise setting of these voltages is provided by fifteen turn potentiometers.

2.5.5 Heat Trace

2.5.5.1 Vent-Thru-Roof Heat Trace, Force Main Discharge, Exterior Water Pipe Heat Trace

The typical heat trace (tape) installed in the New Power Plant is Raychem 5BTV2-CT. It delivers up to 5-watts per foot based on pipe temperature. Heat tape is installed on the domestic water supply and return, waste water supply and return, snow melter piping, and exhaust stack vents.

Manufacturer supplied heat tape is installed in the insulated doors which maintain the building envelope. This heat tape is not self-regulating and is controlled by a variac voltage regulator.

Additional Raychem heat tape connections are provided for emergency fuel oil and raw water piping, emergency force main discharge piping, and emergency glycol heating supply and return piping.

2.5.6 Signaling Systems

2.5.6.1 Telephone

Copper wiring provides telephone connectivity. A telephone device in the New Power Plant is connected to a cross-connect panel in the New Power Plant. This cross-connect panel is, in turn, connected via copper wire to the PBX located in the Dome's Communication Center. The PBX allows telephone voice connectivity to other Station telephones and off-Station telephones. Phone service is provided in each room of the New Power Plant.

2.5.6.2 Public Address System

The Public Address (PA) system has speakers located in the New Power Plant, connected via copper wiring. The PA provides general Station announcements and New Power Plant fire announcements.

The PA system control is located in the Dome's Communication Center and connects to the New Power Plant via copper wire. The PA system can be accessed via the telephone system or the communications center for general announcements. The PA integrates with the New Power Plant's fire protection system to produce fire announcements in the New Power Plant.

The New Power Plant PA has an amplifier that receives power from the New Power Plant. In the event of a power outage, the PA system will not function, but the fire protection alarms and strobes will function.

2.5.6.3 Local Area Network (LAN)

Copper wire provides LAN connectivity between the New Power Plant and the Station network. A PC connects to a port on a hub in the New Power Plant, which connects via fiber optic to a port on a router located in the Dome's Communications Center. The router in the Dome provides connectivity to file servers, email, and the Internet.

The LAN is dependent on power in the building to power the hub and PC. If the hub fails, it will cause the LAN to become inoperative and connectivity to the Station LAN will be lost. Failure of either the PC or the copper connection to the hub will cause that PC to lost its connection to the LAN.

The Station LAN's main file servers reside in the Dome's Communications Center and have an Uninterruptible Power Supply (UPS) providing power for emergency conditions. A cable plant design is under development which will identify the types and physical location of cables connecting the Station Network.

2.5.6.4 Video Surveillance (Future)

2.5.6.5 CCTV (Future)

2.5.6.6 Fire Detection and Alarm System

The fire detection and alarm system is a microprocessor addressable type system that provides early detection of smoke and/or heat produced by fire. It provides a pre-discharge alert for the Carbon Dioxide Extinguishing System, (Section 2.4.5.1). This pre-discharge alarm signal will allow occupants to evacuate the facility. This system is configured to be interconnected with the future Station-wide addressable system.

The system includes a new control panel located in the New Power Plant Control Room, a graphical display annunciation panel in the Vestibule, heat detectors, smoke detectors, manual pull stations, horn/strobe alarm stations and duct mounted smoke detectors. In potentially high-noise areas, high volume horn/strobe units are provided.

All pull stations, detectors, and sensors report to the fire alarm control panel. The control panel sounds alarms and indicates the position of the fire (or smoke) on its own display and on a graphical panel located in the Vestibule. The control panel interfaces with, and controls operation of, the Kidde PEGAsys CO_2 release panel located in the Control Room. After a CO_2 discharge, the control panel must be manually reset before the PEGAsys panel will reset. The control panel interfaces with, and controls operation of the Kidde PEGAsys CO2 releasing panel located in the Control Room. PEGAsys After a CO_2 discharge, the control panel must be manually reset before the PEGAsys panel will reset. In conjunction with the PEGAsys CO_2 panel, the FDAS CO_2 discharges valves and bypasses switches.

For general fire alarm and detection system drawings, refer to the Life Safety Systems, Inc. sheets, 98-1147, 98-1147A - 98-1147H, Section 4.2.4.7.6, Appendix VII. Refer to American Fire Systems, Inc. sheets P1.0 - P1.4, and D1.0 for details of the Kidde PEGAsys CO_2 release system.

2.5.6.6.1 Fire Detection and Alarm Control Panel

The Fire Alarm and Control Panel (FACP) is located in the Power Plant Control Room. This panel is a Cerberus Pyrotronics MXL Panel. It is the control information center for the fire protection system. The panel displays modes for normal operation, trouble, testing, drill, and alarm conditions. The panel face contains an 80-character display, alarm silence buttons, and seven indicator lights. It contains a keyboard interface that is accessed with a key.

When any device (heat, smoke or manual pull station) is activated, the alarm panel initiates an audible and visual alarm (horn/strobe) throughout the building and PA system alarm inside the Arch. At the same time AHU fans serving the zone are commanded off, causing air dampers to go to fire-safe positions. An alarm signal is also transmitted to the DDC System and to the Control and Monitoring System (CMS) in the existing station. An LED will illuminate on the Vestibule graphic annunciation panel to show the relative location of the activated device.

The building must be evacuated on the activation of this first alarm. The designated individual(s) will respond to the location and take the appropriate action. CO_2 is not released on the activation of a single device. It requires activation of two devices in the same zone (Zones 1 through 5 only), or one manual device to begin the CO_2 discharge sequence.

A 30-second, distinct, audible and visual, CO_2 pre-discharge alarm commences prior to CO_2 release. This second alarm shuts down the engine/generators and closes the fuel supply valves to them. It causes fire dampers to close to the CO_2 protected zone. At the end of 30 seconds, CO_2 is released to the zone containing the two detectors that activated. Zones are identified as follows.

Zone No.	Fire Alarm Zone
1	Generator #1
2	Generator #2
3	Generator #3
4	Generator #4
5	Fuel Room
6	Control Room and Corridor
7	Power Generation Room
8	Remote Radiator Room

Fire Zone Numbers and corresponding areas

9	Substation Room
10	Water Treatment, Accessory Rooms and Toilet
11	Arch
12	Air Handling Units

Fire Zone Numbers and corresponding areas

The main system power supply is at the alarm control panel. It contains rechargeable battery back-up, with capacity for operating the system in standby mode for 48 hours followed by full system alarm mode of 15 minutes.

2.5.6.6.2 CO_2 Releasing Panel

The CO_2 Releasing Panel is located in the Control Room. It is a self-contained panel which receives its activation signals from the FACP. It displays modes for normal operation, trouble, testing, drill, and alarm conditions. The panel face contains an 80-character display, alarm silence buttons, and seven indicator lights. It contains a keyboard interface that is accessed with a key.

When the FACP receives its second signal, it starts its 30-second timer for CO_2 release. After the 30 seconds expires, a signal is sent to the corresponding zone of the CO_2 Releasing Panel. Upon receiving this signal, the CO_2 Releasing Panel sends a release signal to the Main or Reserve cylinder bank, depending on the position of the Main/Reserve Switch.

In the case of the Fuel Room, CO_2 is immediately discharged into the room. In the case of the Generator Room, there is an additional ten second delay to ensure that all CO_2 cylinder control heads operate. After this 10 seconds, CO_2 is released to the corresponding zone (generator).

WARNING:

Each CO_2 release discharges a lethal concentration of CO_2 into the room. Evacuate the room and Arch immediately on hearing or seeing the pre-discharge alarm. Only qualified personnel equipped with SCBA should re-enter the Arch or building until all CO_2 has been removed by the building exhaust system.

2.5.6.6.3 Initiating Devices

Heat detectors are fixed-temperature/rate-of-rise type in warm areas. Near outside doors and the entry vestibule, where temperatures may change quickly, fixed-temperature only detectors are used. Outside the building but inside the Arch, weatherproof all-metal heat detectors and manual pull stations are used.

Space smoke detectors are photoelectric type. Smoke detectors are used in areas not subject to frequent visits by occupants or where combustion may not be immediately noticed. Photoelectric type smoke detectors with sampling tubes are used to detect smoke inside ductwork. The receipt of an alarm from any device within the Power Plant Building will result in the shutdown of AHU's to the affected building.

2.5.6.6.4 Signaling Appliances

A graphical annunciator panel is located in the vestibule to display the building floor plan with LEDs to indicate the area within the power plant or outside the building (inside the Arch) initiating trouble or alarm.

Audible/visual alarms are combination horn/strobe units. The Arch area uses the public address system (PA) speakers for alarm annunciation. These speakers are external weatherproof all-metal construction. These speakers are external weatherproof all-metal construction.

2.5.6.6.5 Auxiliary Devices

Door holders, air handling fans, and smoke/fire dampers in ducts interface with the fire alarm system to prevent smoke from traveling to all areas of the building. When the system is in alarm, the door holders will release and close fire doors. The dampers in the ductwork go to a fire safe position and air handling fans turn off.

If any of the above actions occur and the Fire Alarm System is not in alarm, the designated individual must be contacted to determine the source of failure.

In the event of a total system failure and no signal is available for CO_2 release, there are Emergency Manual CO_2 release valves located at the CO_2 tanks.

3 MAINTENANCE

3.1 GENERAL BUILDING MAINTENANCE

The New Power Plant and ancillary facilities (Building 103 and Arch) are comprised of three major building systems: architectural/structural, mechanical and electrical. To ensure that critical and elementary components of these systems consistently operate at their maximum performance levels, preventative, predictive, and corrective maintenance practices are required at periodic intervals. The information contained in these Maintenance sub-sections provide a basic outline of the general building systems, sub-systems, associated equipment, and their respective inspection, servicing and maintenance requirements. Preventative maintenance shall be performed per the applicable referenced PM procedures at the recommended intervals. Corrective maintenance shall be performed in accordance with the latest editions of the National Fire Protection Association (NFPA), National Electrical Code (NEC), Uniform Plumbing Code (UPC), Uniform Mechanical Code (UMC), and the Uniform Building Code (UBC).

(FPN:) Referenced preventative maintenance frequencies shall be as follows:

Daily (every day), Weekly (every week), Monthly (every month), Quarterly (every three months), Semi-Annual (every six months), Annual (every year), Bi-Annual (every two years), Tri-Annual (every three years)

3.2 ARCHITECTURAL/STRUCTURAL SYSTEMS

3.2.1 Building Systems

3.2.1.1 Foundation Leveling/Jacking

Periodic leveling of the building may be required due to differential settling of the foundation footings. Leveling requirements are determined based on sighted-in survey points within the crawlspace. The building is leveled utilizing hydraulic jacks at “jacking points” (located adjacent to support columns). Base plates are loosened and shim plates are added and/or removed as required.

Appendix 4.2.1.1.1 provides a description and diagrams for leveling the New Power Plant.

3.2.1.2 Entrance Grating

The fiberglass grating is corrosion resistant, resilient, non-magnetic and maintenance free.

3.2.1.3 Fuel/Lube Oil Containment Sills

Conduct visual inspections on a regular basis to evaluate the integrity of the sills.

3.2.2 Windows and Doors

3.2.2.1 Windows

During performance of the annual building inspection (PM #0350FA), inspect all windows for seal integrity, damage, and proper operation. Repair damaged and/or deficient windows to maintain the integrity of the building envelope.

3.2.2.2 Doors

During performance of the annual building inspection (PM #0350FA), inspect all doors for structural integrity, damage and proper operation. Additional periodic inspections of doors in heavy traffic areas shall be performed as determined necessary.

3.2.2.3 Sound Control Doors

Sound control doors are provided to isolate high ambient sound between the Power Generation Room and the occupied portions of the building. Sound control doors are included with the door inspections under PM #0350FA.

3.2.2.4 Cold Storage Doors

The exterior cold storage doors (equipment #DO30067, #DO30068 and #DO30069) of the New Power Plant are critical for maintaining the building envelope and protecting its contents from the environmental elements.

A semi-annual inspection is required and performed in accordance with PM #0128FS, which includes the following:

Lubrication: In normal service, it is recommended that a few drops of light oil be used on all moving parts and the drive chain be wiped with a cloth dampened with oil or a suitable rust inhibitor. Specialized cold environment lubricants may be used as applicable.

CAUTION:
In areas that are washed down with degreasing chemicals, electrical components must be protected and lubricants washed from operator and other moving parts must be replaced immediately.

Wax the inner edge of the door to allow for smooth contact between door and gasket.

Sealant: During the life of the door it is possible for the factory sealant (silicone) in the seams and joints to come loose, either from abuse and/or normal use. It is critical that all seams and joints are kept vapor tight at all times.

Inspections of seams and joints for loose or missing sealant should be performed. Replace sealant in problem areas.

NOTE:
Failure to maintain the sealant in problem areas will affect the vapor seal integrity and cause deterioration of the door.

Inspect all operators for smooth operation. Adjust latches and strikes to maintain the proper pressure on perimeter gaskets. Check all fasteners and retighten as required.

Inspect and verify electrical connections and heater operability. Verify that proper voltage (120 volts) and proper current is present.

Refer to cold storage door drawings and details in Appendix 4.2.1.2.4.

3.2.2.5 Finish Hardware

During performance of the annual building inspection (PM #0350FA), inspect all door hardware for proper operation. This includes all adjacent passageway doors within the New Power Plant.

Mechanical door closers should operate smoothly, keep the door under orderly control at all times, and provide sufficient leverage to close against the latch.

Knobs/levers and latch bolts should operate smoothly without undue force. Latch bolts on passage/non-keyed entry devices shall operate from either side of doors at all times. Latch bolts on keyed entry devices shall be retracted by key outside of door or by knob/lever inside door.

Pay special attention to emergency panic bar exit devices and periodic inspections. Check the devices for smoothness of operation. Any binding or dragging may indicate worn parts or the need for lubrication. Check the devices for full extension of the latch bolt and full retraction during operation. Short extension may indicate binding, and insufficient retraction indicates worn parts or vertical rods out of adjustment. The latch bolt should retract fully when dogged. Check the deadlocking function by depressing the latch bolt when engaged with the strike. If the latch bolt fully retracts, strike or vertical rod adjustment may be necessary.

Periodic lubrication is required to inhibit excessive wear of working parts. For normal to heavy traffic areas, good commercial grease is sufficient for proper operation.

For devices exposed to adverse conditions and/or abnormally high exposure to dust and dirt, a graphite or silicone-based lubricant can be used at more frequent intervals.

Inspect all hardware for missing or loose fasteners and replace and/or retighten as necessary.

Refer to door hardware details in Appendix 4.2.1.2.5.

3.2.3 Interior Finishes

3.2.3.1 Sheet Vinyl Flooring

Routine and proper cleaning of the sheet vinyl floor is essential. Depending on area usage, a typical routine may involve daily sweeping and damp mopping, complemented by scrub cleaning once or twice a week.

Repair damage to the floor coverings as soon as possible. The polyurethane adhesive slows down water migration but will not prevent it. Cuts in the flooring may be heat welded in order to create a seal against moisture intrusion.

Refer to Cleaning and Maintenance booklet in Appendix 4.2.1.3.1.

3.2.4 Interior Specialties/Fixtures

3.2.4.1 Miscellaneous Specialties

3.2.4.1.1 Fire Extinguishers

Annual maintenance of the ABC or multi-purpose extinguishers is performed by the Operations Fire Department in accordance with NFPA 10.

3.2.4.1.2 Daylighting Tubes

Solatubes are maintenance free. The sealed system locks out dust and moisture.

3.3 CONVEYING SYSTEMS

3.3.1 Rolling Gantry Hoists

A rolling gantry hoist is used within the Power Generation room to maintain engine generators. The gantry straddles the engine generator on each side.

The tri-adjustable rolling gantry (equipment #H030007) has a 10-ton capacity, 9'6" span and 9'9" to 15'1" overall height.

The manual lift chain hoist (equipment #H030011) has a 5-ton capacity and 18" retracted height (hook-to-hook).

Proper operation and maintenance of the gantry crane is performed in accordance with ANSI and OSHA 1910.179. Refer to PM #6207FA and #6207FQ.

3.4 MECHANICAL SYSTEMS

3.4.1 Heat Generation and Distribution Systems

3.4.1.1 Auxiliary Fuel-Fired Boiler

The auxiliary boiler provides back-up heat to the perimeter heating system. The fuel-fired boiler (equipment #BH30010) requires daily, weekly, monthly, quarterly, semi-annual, and annual inspections to maintain proper operation and fuel economy.

Daily, check and record/log pressures, glycol and stack temperatures, and fuel usage.

Weekly, inspect burner flame, linkages, valves, and pumps. Refer to PM #0500FW.

Monthly, check safety shutdown components, temperature limit switches, and flame safeguards in accordance with PM #0500FM.

Quarterly, inspect ignition assemblies, air intake elements, and fuel filtering in accordance with PM #0500FQ. Clean nozzle and ignition assemblies, verify alarm indicators, and lubricate motors.

Semi-annually, clean and inspect burner components, change oil filters, operate relief valves, check wiring connections, and record amperages in accordance with PM #0500FS.

Annually, perform a complete and thorough inspection of the boiler in conjunction with inspection by a “Boiler Inspector.” Perform hydrostatic tests. Tear down and clean fire-side and water-side sections. Inspect all boiler operational parameters and verify they are in working order. Refer to PM #0500FA and #0163FA.

Refer to Start-Up, Service, and Maintenance Instructions in Appendix 4.2.3.1.1.

3.4.1.2 Terminal Heat Transfer Units

3.4.1.2.1 Unit Heaters

WARNING:
Allow rotating fans to stop before servicing to avoid serious injury to fingers and hands.

Annually, inspect and lubricate the unit heaters (equipment #HT30140 through #HT30148) in accordance with PM #0166FA.

Lubrication, Sleeve Bearings: The frequency of oiling will depend upon operating conditions and length of running time. Inspect the oilers or oil holes when the unit is cleaned.

Lubrication, Ball Bearings: Ball bearing motors are pre-lubricated and do not require on-the-job lubrication.

Cleaning: Clean the unit casing, fan, diffuser, and coil thoroughly once a year. Clean and repaint any rust spots on the casing.

3.4.1.2.2 Cabinet Unit Heaters

WARNING:
Allow rotating fan to stop before servicing equipment. Failure to do so may cause severe personal injury or death.

Monthly, inspect the unit air filters of the cabinet unit heaters (equipment #HT30137) and clean or replace dirty filters.

Annually, inspect the fan wheel, housing, coil fins, and strainer. Clean and tighten electrical connections. Refer to PM #0166FA.

Refer to Installation, Operation, and Maintenance Manual in Appendix 4.2.3.1.2.2.

3.4.1.2.3 Finned Tube Heaters

WARNING:
Follow all directions provided with chemical cleaners to avoid personal injury and/or coil damage. Commercially available chemical cleaners may contain caustic or hazardous agents.

Perform maintenance on a quarterly basis in accordance with PM #0194FQ. Clean fins on the finned tube heaters (equipment #HT30138 and #HT30139). Inspect all connections and tighten if necessary.

3.4.1.3 Heating Coils

Heating coils are part of the air handling units and are designed to temper the air.

Perform a semi-annual inspection of the coils for dirt build-up and/or freeze-up. Refer to PM #0172FS.

3.4.1.4 Heat Exchangers

WARNING:
Proper precautions must be taken (special clothing, equipment, etc.) to protect personnel from injury due to escaping fluids or hot exchanger surfaces.

The New Power Plant utilizes three types of heat exchangers:

Plate and Frame: (equipment #EE30012 and #EE30013)

Clean the heat exchanger surfaces on a regular basis. Grease the threads of the tie rods and protect from corrosion and damage with protection sleeves. Also, grease the ball bearings under the tie rod nuts on a regular basis.

Shell and Tube: (equipment #EE30014 and #EE30018 through #EE30021)

WARNING:
It is extremely important to follow a proper flange tightening sequence. If not followed, the flanges can become cocked and a leak will result. When tightening flanges with spiral wound gaskets, if cocking occurs, the result can be deformation and non-repairable damage to the gaskets in addition to a resultant leak. Any gasket leak can result in potential injury to adjacent personnel.

CAUTION:
Neglect in keeping all tubes clean may result in complete stoppage of flow through some tubes with consequent overheating of these tubes, resulting in severe expansion strains, leaking tube joints, and damage to the heat exchanger.

CAUTION:
When tightening leaking tube joints:

- **Do not roll tubes beyond the back face of the tubesheet. Maximum rolling depth should be the tubesheet thickness minus 1/8".**
- **Do not re-roll tubes that are not leaking since this will thin the tube wall.**

The result of either of the above conditions can lead to failure of the tube and a leaking bundle.

CAUTION:
Field repair of Diamondback™ double wall heat exchangers is not recommended. Rerolling of the tube joints may result in the closing of the leak detector flow paths between the two tube walls preventing the heat exchanger from providing a positive indication of potential cross contamination.

CAUTION:
When cleaning a tube bundle, tubes should not be hammered on with any metallic tool and, in case it is necessary to use scrapers, care should be exercised that the scraper is not sharp enough to cut the metal of the tubes.

Clean the interior and exterior tubes on a frequent and regular basis depending on the amount of scale build-up. Refer to the Installation, Operation and Maintenance Manual in Appendix 4.2.3.1.3.

Exhaust Heat Recovery Silencer: (equipment #EE30015 through #EE30017)

The heat recovery silencer has no moving parts and requires little routine maintenance. Periodically, inspect the connection for tightness and clean the soot from the unit. After cleaning, install new gaskets.

Refer to Installation, Operation and Maintenance Instructions in Appendix 4.2.3.10.3.3.

Perform maintenance for all heat exchangers in accordance with PM #6860FA.

3.4.1.5 Glycol Pumps

Glycol pumps (equipment #PU30071 through #PU30078) provide fluid flow for the hydronic system under control of the Direct Digital Control (DDC) system.

Perform maintenance in accordance with PM #0165FA, #6218FQ, and #6218FA.

WARNING:
Electrical Shock Hazard—Electrical connections to be made by a qualified electrician in accordance with all applicable codes, ordinances and good practices. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

> **WARNING:**
> **Electrical Overload Hazard—Three phase motors must have properly sized heaters to provide overload and under voltage protection. Single phase motors have built-in overload protectors. Failure to follow these instructions could result in serious personal injury, death and/or property damage.**

> **WARNING:**
> **Extreme Temperature Hazard—If the pump, motor, or piping are operating at extremely high or low temperature, guarding or insulation is required. Failure to follow these instructions could result in serious personal injury, death and/or property damage.**

> **WARNING:**
> **Hot Water Hazard—When disassembling a gasketed joint, always use a new gasket upon reassembly. Never re-use old gaskets. Failure to follow these instructions could result in serious personal injury, death and/or property damage.**

> **WARNING:**
> **Unexpected Start-Up Hazard—Disconnect and lockout power before servicing. Failure to follow these instructions could result in serious personal injury, death and/or property damage.**

> **WARNING:**
> **Excessive System Pressure Hazard—The maximum working pressure of the pump is listed on the nameplate—do not exceed this pressure. Failure to follow these instructions could result in serious personal injury, death and/or property damage.**

> **WARNING:**
> **Excessive Pressure Hazard—Volumetric Expansion—The heating of water and other fluids causes volumetric expansion. The associated forces may cause failure of system components and release high temperature fluids. This can be prevented by installing properly sized and located compression tanks and pressure relief valves. Failure to follow these instructions could result in serious personal injury, death and/or property damage.**

Quarterly, inspect motor/pump alignment, flexible coupling, mounts and bearings, gauges, seals, pump and motor blocks, oil level, and motor operation. Clean the unit and tighten fittings. Refer to PM #6218FQ.

Annually, check the operational parameters and clean and lubricate the unit. Check for damaged insulation and tighten loose connections. Refer to PM #6218FA.

Refer to the Instruction Manual in Appendix 4.2.3.1.4.

Booster pumps (equipment #PU30082 through #PU30085) are designed for quiet operation in solar and hydronic systems. Lubricate pumps every 6 months.

CAUTION:
Over oiling of the pump will result in the overflow of oil from the oil reservoir and spillage onto surrounding surfaces.

WARNING:
Unexpected Start-Up Hazard—Single phase motors are equipped with automatic reset overload protectors. The pump can restart without warning. Disconnect and lockout power before servicing. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

WARNING:
Hot Water Hazard—Before draining the system, allow water to cool to at least 100^{o}F, open the drain valve (take precautions against water damage) and leave the drain valve open until servicing is complete. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

WARNING:
High Pressure Hazard—Pressure may be present in the pump body. This pressure can be relieved by loosening the flange bolts and shifting the pump assembly slightly to allow the pressurized water to escape. Failure to follow these instructions could result in serious personal injury or death.

Refer to Instruction Manual in Appendix 4.2.3.1.4.

3.4.1.6 Hydronic Piping

Perform visual inspections of the hydronic piping as part of the hydronic system inspection. Refer to PM #0523FW.

3.4.1.7 Hydronic Specialties

3.4.1.7.1 Expansion Tanks

These 135-gallon tanks (equipment #TE30038 through #TE30041) are designed to absorb the expansion forces and control the pressure in heating/cooling systems.

Check tanks for rust and leaks, paying particular attention to connections in accordance with PM #0504FS.

3.4.1.7.2 Air Separators

Air separators (equipment #SA30004 through #SA30009) remove and control air in a hydronic system.

WARNING:
Leakage, corrosion or indications of damage are signs of an impending serious failure of the Airtrol component. Periodically inspect all components for damage and if noted the Airtrol component must be serviced or replaced. Failure to follow these instructions could result in serious personal injury or death and property damage.

WARNING:
System fluid under pressure and/or at high temperature can be very hazardous. Before proceeding to service strainer, reduce system pressure to zero or isolate the Rolairtrol from the system. Allow the system to cool below 100^{o}F. Failure to follow these instructions could result in serious personal injury or death and property damage.

Clean strainers periodically in accordance with PM #0161FS.

3.4.1.7.3 Flow Controls

Hydronic flow controls are externally adjustable controls. Inspect control valves annually. Clean strainers periodically. Cartridges may need to be changed periodically. In most cases both the control range and the flow rate can be changed by replacing the cartridges.

3.4.1.7.4 Balance Valves

The balance valves are calibrated for use as a presettable balance valve, variable orifice flow meter, and positive shut-off service valve.

Valves are furnished with a calibrated nameplate and memory stop indicator that permits the valve to be preset to a fixed position, and then closed for service without disturbing the valve setting.

WARNING:
Hot fluid leaking from valve can cause burns. Avoid contact with leaking fluid while servicing valve. Failure to follow these instructions could result in serious personal injury or death and property damage.

Check valves periodically for signs of leakage, corrosion, or damage.

3.4.1.7.5 Relief Valves

Relief valves are designed to protect fired and unfired hot water pressure vessels against over-pressure conditions.

WARNING:
Corrosion, scale buildup, leakage, or damage to safety relief valves are indications the safety relief valve may fail to provide over pressurization protection. Every 30 days the safety relief valve must be inspected and if any of the above conditions are noted it must be replaced. Failure to follow these instructions could result in serious personal injury or death and property damage.

WARNING:
Attempts to change safety relief valve settings will prevent it from relieving at rated capacity and thus causing the system/component to explode. Do not attempt to adjust the pressure setting of the safety relief valve. Failure to follow these instructions could result in serious personal injury or death and property damage.

Check the operating condition of the safety relief valves every 30 days, or after any prolonged period of inactivity. Check the relief valve by manually operating the lever on top of the relief valve to the full open position, releasing the lever and allowing the valve to snap closed, and inspecting the relief valve for leakage. When performing the manual test, inspect the safety relief valve for signs of corrosion, damage, or scale buildup.

Refer to Instruction Manual in Appendix 4.2.3.1.6.5.

3.4.1.7.6 Glycol Make-up Systems

The glycol make-up package (equipment #SY30050) is designed to continuously monitor the heating system pressure.

Check the glycol solution level in the translucent solution container and replenish as necessary.

The glycol make-up package is designed to operate without the need of servicing or adjustment. The pump is equipped with self-lubricating carbon bearings, and the motor is a life-time lubricated type for standby make-up applications. The pump has a seal type packing that does not require adjustment.

3.4.1.7.7 Hydronic Meters

Hydronic meters (equipment #GA30008 through #GA30017) measure the glycol fluid.

Perform calibration checks annually in accordance with PM #0198FA.

Refer to Installation, Operation, and Maintenance guidelines in Appendix 4.2.3.1.6.8.

3.4.1.8 Emergency Snow Melter (Future)

3.4.2 Ventilation Systems

3.4.2.1 Air Handling Units

AHU-1 (equipment #AH30035) and AHU-2 (equipment #AH30036) are located in the Power Generation Room. They provide combustion air to the engine generators and the auxiliary boiler as well as make-up air for exhaust fans EF-1 and EF-2.

Refer to the Installation and Maintenance Manual in Appendix 4.2.3.3.1.

AHU-3, AHU-4 and AHU-5 are small cabinet fans. AHU-3 (equipment #AH30037) is located in the Control Room and provides ventilation, cooling, and positive pressurization for the Control Room and Accessory Room.

AHU-4 (equipment # AH30038) is located in the Substation Room and provides cooling air to the Substation.

AHU-5 (equipment #AH30039) is located in the Control Room and transfers make-up air provided by AHU-1 and AHU-2 to EF-1 and EF-2.

WARNING:
Disconnect electrical power and allow rotating parts to stop before servicing the units. Exercise caution if units must be on for test or maintenance procedures. Failure to do so may result in injury or death from electrical shock or moving parts.

> **WARNING:**
> **Disconnect electrical power prior to access into a fan or ductwork. Even when locked out electrically, fans may cause injury or damage if the impeller is subject to "windmilling." The impeller should be secured to physically restrict rotational movement. Failure to secure impeller can cause severe personal injury or death.**

Monthly, check air filters, lubricate fan/motor bearings, and check/adjust fan belt tension. Refer to PM #0172FM.

Semi-annually, check electrical wiring and connections, drain pans, grease line connections, motor lubrication, fan belt tension, and inspect coils for dirt build-up and/or freeze-up. Refer to PM #0172FS.

Annually, inspect the unit casing, clean fan wheels, check damper linkages/ operators, inspect V-belts, check drain pans, and check insulation/gasketing. Clean and/or replace air filters as required. Inspect and lubricate motors. Inspect coils for dirt build-up, microbial growth, and clean as required. Refer to PM #0172FA.

3.4.2.2 Ventilation Fans

> **WARNING:**
> **Disconnect and secure in the "off" position all electrical power to the fan prior to inspection or servicing. Failure to comply with this safety precaution could result in serious injury or death.**

Quarterly, inspect ventilation fans (equipment #FN30036) in accordance with PM #0169FQ. Check belt tension and bearings. Examine fasteners and set screws for tightness. Thoroughly clean the exterior surface of the motor, fan panel, and entire propeller.

Semi-annually, lubricate fan shaft bearings with grease fittings.

Refer to Installation, Operating and Maintenance Manual in Appendix 4.2.3.3.2.

3.4.2.3 Exhaust Fans

The exhaust fans (equipment #FN30034 and #FN30035), which discharges vertically through the Arch, should be inspected once or twice a year.

> **WARNING:**
> **Always disconnect power prior to working on fan. Failure to do so could result in injury or death from electrical shock or moving parts.**

Check unit for any unusual noise or vibration. Check bolts and screws for tightness and belts for wear and alignment. Check bearings, inlet vanes, springs, and rubber isolators for signs of deterioration. Check fan motor and wheels for dust and dirt accumulations. Clean exterior surfaces. Check motor for lubrication.

Refer to PM #0169FQ and the Maintenance Suggestions in Appendix 4.2.3.3.3.

3.4.2.4 Exhaust Hoods

Building exhaust for remote radiators discharges through the downwind bulkhead. Check for accumulation of snow, ice, and debris around wire mesh outlet screens to prevent obstruction of air flow.

Refer to the exhaust hood drawing in Appendix 4.2.3.3.4.

3.4.2.5 Outside Air Intake

Air is brought into the Arch through an opening in the upwind bulkhead. There are no fans or control devices installed in the Arch outside air opening. Outside air for use in the building is brought in through the floor and ducted to the individual air handling units. Check for accumulation of ice and debris around wire mesh inlet screens to prevent obstruction of air flow.

3.4.2.6 Relief Air Hood

All relief air discharges extend through the downwind bulkhead and relieve outside the Arch. Check for accumulation of snow, ice, and debris around wire mesh outlet screens to prevent obstruction of air flow.

3.4.2.7 Air Outlets and Inlets

Check all grills, registers, and diffusers periodically for obstructions and accumulation of dirt and debris. Inspect for any corrosion or damage. Check adjustable louvers and diffusers for proper positioning.

3.4.2.8 Soundtraps

Perform maintenance as part of the ventilation system inspection.

3.4.2.9 Air Cleaning Devices

Air filters are provided to remove particulates from the air and protect the fans and coils of air handling equipment from dirt and debris build-up, which can adversely affect the performance of the equipment. Air filters are replaced based on specific equipment requirements and the operating environment. Air handling unit air filters are checked regularly during performance of PM #0172FM and #0172FA.

3.4.2.10 Dampers

To maintain proper volume control, air balance, and fire boundary integrity, dampers must operate properly.

> **WARNING:**
> **When operating dampers, keep fingers and clothing away from damper blades.**

Inspect damper actuators, louvers, linkages, springs, counterweights, and seals for damage and operability.

Check back draft dampers for spring return full closure in the absence of air flow to prevent air infiltration.

Check volume control dampers for full range smooth operation. If dampers are motorized, check dampers for full range motor driven operation.

Fire dampers shall be maintained in intervals as stated in NFPA 90A and 92A.

3.4.3 Plumbing

3.4.3.1 Plumbing Piping

3.4.3.1.1 Sanitary Sewer/Vent Piping

Perform visual inspections of the sanitary sewer/vent piping as part of the plumbing system inspection. Refer to PM #0208FW and #0208FS.

3.4.3.1.2 Domestic Water Piping

Perform visual inspections of the domestic water piping as part of the plumbing system inspection. Refer to PM #0189FW and #0195FW.

3.4.3.2 Plumbing Equipment

3.4.3.2.1 Pressure Booster Systems

The pressure booster system (equipment #SY30069) is a complete packaged system, including pump, bladder tank, and electrical control panel. Preventative maintenance is performed in accordance with PM #6218FQ and #6218FA.

WARNING:
Unexpected Startup Hazard—Disconnect and lock-out power before servicing. Failure to follow these instructions could result in serious personal injury or death, and property damage. Do not touch the internal electrical control panel components while the power is on or controller failure, personal injury or death could occur.

WARNING:
Extreme Temperature Hazard—Allow pump temperature to reach acceptable level before proceeding. Open drain valve, do not proceed until liquid stops coming out of drain valve. If liquid does not stop flowing from drain valve, isolation valves are not sealing and should be repaired before proceeding. After liquid stops flowing from drain valve, leave drain valve open and continue. Remove the drain plug located on the bottom of the pump volute. Do not reinstall plug or close drain valve until reassembly is completed. Failure to follow instructions could result in moderate personal injury or property damage.

WARNING:
Excessive Pressure Hazard—Make certain the internal pressure is relieved before continuing. Failure to follow these instructions could result in serious personal injury or death and property damage.

Inspect piping, connections, and ancillary components for leakage and corrosion. Inspect the tank for signs of corrosion or damage.

Refer to installation, operation, and maintenance instructions in Appendix 4.2.3.5.1.

3.4.3.2.2 Sanitary Waste Water Storage Tank

The sanitary waste storage tank (equipment #TN30008) is a wastewater holding tank, gravity fed from the plumbing appliances, and equipped with manual pump-out capabilities.

Periodically check tank for corrosion or damage in accordance with PM #0208FW and #0208FS.

Refer to drawing in Appendix 4.2.3.4.1.1.

3.4.3.2.3 Sewage Ejector Pump

The sewage ejector pump (equipment #PU30086) requires periodic motor, pump thrust bearing, and pump intermediate and lower bearing lubrication. Refer to PM #6218FQ and #6218FA.

WARNING:

- **Never work alone. Use a lifting harness, safety line and a respirator as required. Do not ignore the risk of drowning.**
- **Make sure that there is sufficient oxygen and that there are no poisonous gasses present.**
- **Check the explosion risk before welding or using electric hand tools.**
- **Do not ignore health hazards. Observe strict cleanliness.**
- **Bear in mind the risk of electrical accidents.**
- **Make sure that the lifting equipment is in good condition.**
- **Provide a suitable barrier around the work area, for example a guard rail.**
- **Make sure you have a clear path of retreat!**
- **All personnel who work with sewage systems shall be vaccinated against diseases that can occur.**

Refer to Installation, Operation and Service Instructions in Appendix 4.2.3.4.1.2.

3.4.3.2.4 Sewage Tank Sparging System

Sparging Valve: The air supplied drain valve is designed to inject air into the sewage storage tank through the sparging tube.

WARNING:
Do not remove or replace any part of this unit while it is under pressure. Serious personal injury and/or damage to the unit may result.

NOTE:
Drain solution may contain lubricants and/or other hazardous chemicals. Be sure to comply with all applicable regulations concerning their disposal.

Clean drain valve periodically depending on rate of accumulation. Leakage, sluggish operation and/or excessive noise (hissing) are indications that the valve should be serviced. (Noise associated with air exhausting during the drain period is normal.)

Visually check the sparging system (equipment #SY30036) for signs of leakage, corrosion, or damage.

Refer to Installation, Operation and Maintenance instructions in Appendix 4.2.3.4.1.4.

3.4.3.3 Plumbing Fixtures

3.4.3.3.1 Water Closet

The water closet is part of the sanitary waste system. Check toilets for leaks, proper working condition, and cleanliness.

3.4.3.3.2 Urinal

The urinal is a waterless type, which uses a liquid trap seal. Clean daily. Add BlueSeal® Trap Liquid monthly. Replace EcoTraps® twice a year. Indication of the need for EcoTrap® exchange is slow urine flow into the trap.

3.4.3.3.3 Lavatory

Check the faucet periodically for leaks, corrosion, or damage.

3.4.4 Water Treatment, Storage and Distribution

3.4.4.1 Treated Water Piping

Perform visual inspections of the treated water piping as part of the water treatment system inspection.

3.4.4.2 Chemical Solution Tanks and Pump Assemblies

Inspect chemical solution tanks (equipment #TN30005 through #TN30007) for fault codes of the pump metering system and for leaking seals. Verify the metering calibration of flow.

3.4.4.3 Chlorine Contact Chamber

Perform maintenance for the chlorine contact chamber as part of the water treatment system inspection.

3.4.4.4 Static Mixers

The static mixers (equipment #MX30004 and #MX30005) are used in the water treatment system to provide an efficient mixing process. They provide long service life and are maintenance free.

Refer to the operational diagram in Appendix 4.2.3.5.4.

3.4.4.5 Treated Water Storage Tanks

Two 3000-gallon tanks (equipment #TN30009 and #TN30010) are used to store treated/domestic water for the station.

Monthly, inspect switch mechanisms, terminals, and check all piping connections for corrosion and tightness.

Conduct tank inspections on a yearly basis.

3.4.4.6 Limestone Contactor

Perform maintenance for the limestone contactors (equipment #TN30011 through #TN30013) as part of the water treatment system inspection.

3.4.4.7 Chlorine Analyzer

This instrument (equipment #IT30037) measures free or total chlorine in water, wastewater, or other process water applications.

Perform maintenance in accordance with PM #0191FW.

Weekly, remove and clean the overflow weir and filter screen. Dislodge any sediment that has collected in the flow tube. Clean any excess reagent, and fill the reagent bottle with the appropriate solution.

Monthly, check calibration and, if necessary, perform a zero and span calibration.

Yearly, clean and condition analyzer, replace PVC cleaning spheres, perform a zero and span calibration, and replace copper cell if necessary.

Refer to the Installation, Operation and Maintenance Manual With Parts List in Appendix 4.2.3.5.7.

3.4.4.8 pH/ORP, Flow, Temperature, and Pressure Monitors/Transmitters

Perform maintenance of the sensors (equipment #CL30004 through #CL30014) as part of the water treatment system inspection.

pH/ORP: A maintenance log is recommended. Soak the sensor tip in pH 4.0 buffer during system maintenance intervals. Plumb in-line applications with a depression (trap) which ensures liquid is maintained around the sensor tip. If sensor dehydration has occurred, soak the sensor tip in pH 4.0 buffer for 24 to 48 hours, then visually inspect the electrode for surface cracks, swelling, or discoloration.

Transmitter: Clean the transmitter casing and window with a soft cotton cloth and a mild liquid soap solution.

Flow/Temperature Sensors: Inspect for build-up of scale and clean as required.

3.4.4.9 Filters

Tastes and odors in the effluent indicate that filters need to be replaced. Should water pressure drop, the prefilter elements are clogged with excess sediment. To extend cartridge life, a larger dirt/rust filter cartridge unit should be installed ahead of the carbon cartridge filter if clogging occurs before the return of bad taste and odors.

3.4.5 Fire Protection System

3.4.5.1 Carbon Dioxide Extinguishing System

Perform maintenance on the carbon dioxide system (equipment #SY30046) in accordance with PMs #6738FM, #6738FQ, #6738FS, and #6738FA.

WARNING:
CO_2 and nitrogen cylinder assemblies must be stored, handled, transported, serviced, maintained, tested, and installed only by trained personnel in accordance with the instructions contained in this manual, NFPA-12, and CGA pamphlets C-1, C-6, G-6, G-6.3 and P-1. CGA pamphlets may be obtained from the Compressed Gas Association, 1725 Jefferson Davis Highway, Arlington, VA 22202-4102.

Before performing maintenance procedures, refer to the material safety data sheets and safety bulletins in the appendix.

WARNING:
All actuation devices (control heads, discharge heads, etc.) must be removed from the system cylinders prior to performing system maintenance. Observe all safety precautions applicable to handling pressurized equipment. Recharge of CO_2 and nitrogen cylinder assemblies must be performed by personnel trained in Kidde CO_2 systems equipment.

Preventive Maintenance:

Perform preventive maintenance as follows:

- Monthly, inspect hazard area system components and check nitrogen cylinder pressure.
- Semi-annually, check CO_2 cylinder weight, test electric control head, and test pressure switch.
- Annually, check nitrogen cylinder pressure, check CO_2 cylinder weight, blow out distribution piping, perform complete system function, and test pneumatic detection system.
- Every 5 years, hydrostatic test all CO_2 and nitrogen system hoses and flexible connectors.
- Every 5 or 12 years, CO_2 cylinder hydrostatic test and N_2 cylinder hydrostatic test.

Post Fire Maintenance:

After a CO_2 system discharge, perform post fire maintenance as follows:

- Recharge and retest carbon dioxide and nitrogen cylinders.

WARNING:
Control head(s) must be in the "set" or "closed" position before attaching to the cylinder valve, to prevent accidental discharge of the carbon dioxide system.

- Reset all control heads on cylinders and stop (directional) valves on multi-hazard systems. Replace any control head that fails to reset properly. Reinstall locking pins. Replace seal wires.

Refer to Design, Installation, Operation, and Maintenance Manual in Appendix 4.2.3.6.1.6.

3.4.5.1.1 Carbon Dioxide Piping

Perform visual inspections of the carbon dioxide piping as part of the fire protection system inspection.

3.4.5.1.2 Storage Cylinders

Perform maintenance for CO_2 cylinders (equipment #CY30000 through #CY30047) in accordance with PM #6738FM, #6738FS, and #6738FA.

WARNING:
Pressurized (charged) cylinders are extremely hazardous and if not handled properly are capable of violent discharge. This may result in serious bodily injury, death and property damage.

CAUTION:
CO_2 cylinders must not be recharged without a retest if more than five (5) years have elapsed from the date of the last test. Retest shall be in accordance with the requirements of CFR 49, Section 173.34. After retest, interior of cylinders must be thoroughly dried and free of residue.

WARNING:
Under no circumstances while performing either cylinder recharge or leak test should a CO_2 cylinder have a discharge head or control head attached to the cylinder valve. When handling carbon dioxide cylinders, observe the following:

- **Each cylinder is factory equipped with a valve protection cap threaded securely over the valve assembly. This device is a safety feature and provides protection during handling.**
- **This protection cap must be installed at all times, except when the cylinder is connected into the system piping, being filled, or leak tested.**
- **The valve protection cap must be stored in a secure place and made readily available for use. Do not move or handle cylinders without the cap installed.**

Monthly, inspect cylinders for damage and ensure there are no obstructions. Refer to PM #6738FM.

Semi-annually, weigh cylinders and record date of the last hydrostatic test. Refer to PM #6738FS.

Annually, inspect all system hoses for corrosion, kinking, or broken stranding in the hose reinforcement. Replace as necessary. Check the last hydrostatic test data and the date last weighed and record data on NFPA Form 13-E. Refer to PM #6738FA.

3.4.5.1.3 Manual Stations

Perform maintenance as part of the fire protection system inspection.

Monthly, ensure that access to remote nitrogen or cable pull stations are unobstructed and there are no obstructions to the operation of the equipment or distribution of carbon dioxide.

Refer to drawings in Appendix 4.2.3.6.1.3.

3.4.5.1.4 Discharge Nozzles

Perform maintenance as part of the fire protection system inspection.

Monthly, inspect discharge nozzles for dirt and physical damage. Replace damaged nozzles. Clean nozzles if dirty or clogged. Where frangible discs are used, ensure they are intact and clean. Look for holes or cuts. Broken discs will allow vapors, oils, etc., from the hazard to enter into the nozzles and system piping and seriously affect or block system discharge.

CAUTION:
Do not paint nozzle orifices. The part number of each nozzle is stamped on the nozzle. Nozzles must be replaced by nozzles of the same part number. Nozzles must never be interchanged, since random interchanging of nozzles will adversely affect proper CO_2 distribution within a hazard area.

Refer to drawings in Appendix 4.2.3.6.1.4.

3.4.5.1.5 Zone Valves/Control Heads

Perform maintenance as part of the fire protection system inspection.

Monthly, inspect control heads attached to CO_2 cylinders, nitrogen cylinders, stop valves, and time delays for physical damage, deterioration, corrosion, distortion, cracks, dirt, and loose couplings. Tighten loose couplings. Replace damaged or missing caps. Replace control head if damage is found. Clean if necessary. Ensure that all control heads, actuation devices, etc., are all in the “set” or “closed” position with the locking pin installed and seal wire intact.

Refer to drawings in Appendix 4.2.3.6.1.5.

3.4.6 Compressed Air System

3.4.6.1 Compressed Air Piping

Check piping weekly for air leaks, damage, and proper support.

Manually drain moisture from air compressor discharge piping at moisture separator and coalescing filter.

3.4.6.2 Air Compressor

The reciprocating air compressor (equipment #CA30014) provides building air to air outlet stations as well as fixed equipment such as the soot catalyst blowdown system and sanitary waste sparging valve. Maintain the reciprocating air compressor in accordance with PMs #6202FA and #6202FQ.

WARNING:
Compressed air has great force. Always release pressure from the compressor and all associated tubing and components before servicing the compressor. Failure to do so can result in severe injury or death.

WARNING:
Hazardous voltage. Always disconnect the power supply before performing any maintenance or repair work on the compressor. Failure to do so can result in severe injury or death.

Daily, check the compressor frame lubricant level. Check the receiver and drain any condensate.

Weekly, inspect and clean the air inlet filter. Clean the exterior of the intercooler. Manually check the relief valves. Clean the cylinder cooling fins.

Monthly, check the belt tension on the v-belt drive. Check and tighten the screws and bolts. Inspect for air leaks. Clean the motor.

Quarterly, inspect and clean compressor valves.

Annually, inspect the lubricant for contamination. Inspect and lubricate the motor bearings.

Refer to the Owner’s Manual in Appendix 4.2.3.7.1.

3.4.6.3 Air Receiver

The duplex air compressor is outfitted with an 80-gallon air receiver tank to provide air storage.

WARNING:
Compressed air has great force. Always release pressure from the compressor and all associated tubing and components before servicing the compressor. Failure to do so can result in severe injury or death.

Check the air receiver tank periodically for corrosion or damage to the pressure vessel and air leakage at valves, fittings, and tubing.

Daily, manually drain condensate from the air receiver utilizing the manual drain valve located at the bottom.

Weekly, manually check relief valves.

Refer to drawing in Appendix 4.2.3.7.2.

3.4.6.4 Air Outlet Accessories

Air outlet stations are located throughout the New Power Plant to facilitate air utilization equipment. Typical air outlets consist of a filter, regulator, and lubricator.

Filter: Open draincock periodically and drain any bowl accumulation. Clean filter with alcohol and blow out from the inside.

Regulator: Depressurize regulator, disassemble, and clean with denatured alcohol.

Lubricator: Fill lubricator with a high quality SAE #10 oil. Lubricator may be disassembled and cleaned with alcohol.

3.4.7 Breathing Air System

3.4.7.1 Intake Air Piping

Perform piping inspections as part of the breathing air system inspection.

3.4.7.2 Breathing Air Compressor

This compressor is used for breathing air service and is fitted with specialized equipment to properly purify and filter the air. It must be maintained in such a manner to meet all applicable federal rules, regulations and codes such as, but not limited to: OSHA 29 CFR 1910.134, Compressed Gas Association commodity specification G-7.1-1989, Grade E breathing air, and/or Canadian Standards Association. The presence of a purification system does not end the requirement for suitable air intake to ensure high quality breathing air.

Preventative maintenance for the breathing air compressor (equipment #CA30010), breathing air bottles (equipment #CA30011) and breathing air filling station (equipment #CA30012) is performed in accordance with PM #0150FW, #0150FM, #0150FS and 0150FA.

The following contains associated maintenance guidelines. Refer to Section 19, “MAINTENANCE SCHEDULE” of the Bauer Compressors High Pressure Breathing Air Compressor Units Instruction Manual for a matrix of applicable instruction manual sections. See Appendix 4.2.3.8.1.

WARNING:
Perform all breathing air compressor equipment operations and maintenance in accordance Section 1, "OPERATING AND SAFETY PRECAUTIONS", Bauer Compressors High Pressure Breathing Air Compressor Units Instruction Manual. Failure to follow any of these procedures or warnings may result in an accident causing personal injury or property damage.

See Appendix 4.2.3.8.1 for application and task specific safety precautions.

Daily, check the compressor oil level. Check the functioning of the oil pump by observing the oil pressure indicated on the oil pressure gauge. Observe air storage system pressure gauges. Replace broken or damaged pressure gauges immediately.

Weekly, check the automatic condensate drainage (where applicable) by opening the manual drain valves. Manual drain systems are maintenance free unless a drain valve becomes defective.

Every 6 months, check air storage system safety valves (normal conditions). Perform a visual inspection. Avoid operating the safety valve, as even one opening can result in leakage.

Annually, have air storage bottles visually inspected internally.

Every 250 hours, clean or replace the intake filter element. Check the oil pump drive v-belt. Check all tube connections for leakage.

CAUTION:
Small diameter, thick wall tubing can be severely distorted by excessive tightening. After constructing a new joint and inspecting it for leaks, it should be opened and inspected for distortion, then retightened no more than is required to seal the joint.

Every 500 hours, check drive v-belts.

CAUTION:
V-belts which are tightened insufficiently, slip, knock, and wear away quickly. V-belts which are too tight may cause damage on both the motor and the compressor.

> **CAUTION:**
> **For maximum service on multiple belt drives, replace all drive belts with a complete new matched set of belts. Used belts are normally worn in their cross sections and stretched to some extent. A new belt will ride higher in the sheave, travel faster, and operate at a much higher tension than used belts. The cord center of a new belt may rupture, allowing it to elongate. If this occurs, the belt will cease to accept its full share of the load, leaving the drive under-belted and wasting a new belt.**

Every 750-800 hours, inspect and clean valves. Replace if necessary.

Every 1000 hours, (or annually, whichever comes first) service the inter-filter elements and final separator element(s). Change oil (petroleum).

> **CAUTION:**
> **To avoid severe damage to the compressor unit when changing from a petroleum oil to a synthetic oil, observe requirements of Section 4.3.1, Bauer Compressor Instruction Manual.**

Check all tube connections for leakage.

Every 2000 hours, replace the valves.

Every 2000 hours, (or annually, whichever comes first) change oil (synthetic).

Every 3000 hours, check pistons and piston rings.

> **WARNING**
> **Always disconnect the power before working on the motor.**

Every 100,000 hours, relubricate the 3-phase drive motor. (normal duty)

Refer to Bauer Compressors High Pressure Breathing Air Compressor Units Instruction Manual in Appendix 4.2.3.8.1.

3.4.8 In-Plant Fuel Oil System

3.4.8.1 Fuel Oil Piping

Perform piping inspections as part of the overall fuel system inspections. Check piping for leakage, damage, rusting, and proper support.

3.4.8.2 Fuel Meters

The fuel meters (equipment #GA30018 through #GA30028) require monthly and annual maintenance. Refer to PM #0115FM and #0115FA.

WARNING:
All internal pressure must be relieved to zero pressure before disassembly or inspection of meters, strainers, air eliminators, any valves in the system, packing gland, and front or rear covers.

Monthly, inspect cover gaskets for leaks. Check bolts. Remove dust cover and inspect for leaks past the packing gland drive shaft housing. Tighten meters and replace cover.

Annually, clean the unit and lubricate moving parts.

Refer to Installation, Operation, and Maintenance manual in Appendix 4.2.3.9.1.

3.4.8.3 Fuel Storage Day Tanks

Two 1,000 gallon fuel storage day tanks (equipment #TF30098 and #TF30099) serve the boilers and power generation equipment.

Perform maintenance in accordance with PM #0156FA and #0157FA.

Annually, examine the tank interior, inspect pump/motor alignment and wear, and inspect plumbing and electrical connections.

3.4.8.4 Fuel Oil Filters

In-line fuel filters are provided in the boiler and generator fuel supply lines to prevent clogging and fouling of the boiler from particulates in the fuel.

Periodic fuel filter replacement is required to maintain fuel purity and adequate fuel flow.

3.4.9 Engine-Generator Set/Engine Systems

To determine maintenance intervals for engine-generator sets (equipment #GS30011, GS30012, and GS30013), use fuel consumption, service hours, or calendar time, whichever occurs first. Experience has shown that maintenance intervals are most accurately scheduled on the basis of fuel consumption. Recommended intervals are as follows:

Daily:

- Conduct walk-around inspection of engine for leaks and loose connections.
- Check engine oil level.
- Check coolant level.

- Check service indicator on air cleaner housing or check air inlet restriction gauge. Service engine air cleaner elements if necessary.

> **WARNING:**
> **When opening the drain valve, wear protective gloves, protective face shield, protective clothing, and protective shoes. Pressurized air could cause debris to be blown and result in personal injury.**

- Inspect, check, and lubricate driven equipment as recommended by the Original Equipment Manufacturer (OEM).
- Record engine operation information daily in order to develop a performance data trend.

> **WARNING:**
> **Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To prevent possible injury, turn the start switch OFF when changing fuel filters or water separator elements. Clean up fuel spills immediately.**

> **NOTE:**
> **Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over any disconnected fuel system components.**

> **NOTE:**
> **Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.**

First 250 Service Hours:

- Check valve lash and adjust. Adjust the valve bridge (if necessary) before setting the valve lash.

> **WARNING:**
> **Be sure the engine cannot be started while this maintenance is being performed. To prevent possible injury, do not use the starting motor to turn the flywheel.**
>
> **Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.**

> **<u>WARNING</u>:**
> **Hot oil and components can cause personal injury. Do not allow hot oil or components to contact the skin.**

- Test SCA Concentration or obtain Level I Analysis.

> **<u>WARNING</u>:**
> **Battery electrolyte contains acid and can cause injury. Avoid contact with the skin and eyes. Always wear protective glasses when working with batteries. Wash hands after touching batteries and connectors. Use of gloves is recommended. Batteries give off flammable fumes which can explode. Ensure there is proper ventilation for batteries which are located in an enclosure. Do not smoke when servicing the batteries.**

- Clean and check electrolyte level of batteries.

- Inspect the condition and adjustment of alternator and accessory drive belts. Examine all drive belts for wear and replace if they show any signs of wear.

- Inspect all hoses for leaks due to cracking, softness, and loose clamps. Replace hoses that are cracked or soft and tighten loose clamps.

> **<u>NOTE</u>:**
> **Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes, or hoses. Repair any loose or damaged fuel and oil lines, tubes, and hoses. Leaks can cause fires. Inspect all lines, tubes, and hoses carefully. Tighten all connections to the recommended torque.**

Every 500 Service Hours:

- Replace oil and filters for engines equipped with a shallow sump.

> **<u>WARNING</u>:**
> **Hot oil and components can cause personal injury. Do not allow hot oil or components to contact the skin.**

Every 1000 Service Hours:

- Replace oil and filters for engines equipped with a deep sump.

NOTE:
Accumulated grease and oil on an engine is a fire hazard. Keep your engine clean. Remove debris and fluid spills each time a significant quantity accumulates on the engine.

- Clean primary fuel filter.

WARNING:
Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To prevent possible injury, turn the start switch OFF when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTE:
Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

- Replace final fuel filter elements.

NOTE:
This procedure must be performed with the engine STOPPED, unless the engine is equipped with duplex fuel filters. If engine is equipped with duplex fuel filters, refer to the Replace Duplex Fuel Filter Elements topic.

- Clean crankcase breathers.
- Inspect engine protective devices.

NOTE:
During testing, abnormal operating conditions must be simulated. Perform the tests correctly to prevent possible damage to the engine. Refer to the Service Manual for the testing procedure.

Every 2000 Service Hours:

- Inspect the crankshaft vibration damper.
- Inspect the engine mounts for deterioration and proper bolt torque.
- Inspection and cleaning is recommended for the turbocharger compressor housing (inlet side).

- Check and adjust the valve bridge and valve lash. Check the valve bridge before setting the valve lash.

NOTE:
Operation of Caterpillar engines with improper valve adjustments will reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

Only qualified service personnel should perform this maintenance. Refer to the Service Manual or your Caterpillar dealer for the complete valve lash adjustment procedure.

WARNING:
Be sure the engine cannot be started while this maintenance is being performed. To prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

Every 3000 Service Hours or 2 Years:

- Drain/clean/replace coolant.

NOTE:
Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

Every 6000 Service Hours:

- Replace water temperature regulators (thermostats) prior to failure.

NOTE:
Failure to replace the water temperature regulator on a regularly scheduled basis could cause severe engine damage.

Caterpillar engines incorporate a shunt design cooling system and require operating the engine with a water temperature regulator installed.

If the water temperature regulator is installed wrong, the engine may overheat, causing cylinder head damage. Ensure that the new water temperature regulator is installed in the original position. Ensure that the water temperature regulator vent hole is open.

DO NOT use liquid gasket material on the gasket or cylinder head surface.

- Inspect water pump(s) for wear, cracks, pin holes, and proper operation. Repair or replace if needed.
- Inspect the starting motor for proper operation. Check and clean all electrical connections. Listen for a grinding sound when starting the engine. Inspect the flywheel ring gear and starter pinion for wear. Check for wear patterns on the gear teeth. Check for broken and chipped teeth.
- Inspect the alternator for loose connections and proper battery charging. Inspect the ammeter gauge during engine operation to ensure the batteries and/or electrical system is performing correctly. Make repairs as necessary.

WARNING:
Do not disconnect the air line from the air compressor (if equipped) without purging the air and/or auxiliary air systems. Failure to purge the air systems before you remove the air compressor could cause personal injury.

WARNING:
DO NOT store alcohol (for cold weather operation) in the operator area. Alcohol is highly flammable and toxic.

Top End:

- Inspect, rebuild, or exchange cylinder head assembly.
- Exchange/replace electronic unit injectors.

Overhaul:

- Inspect, rebuild, or exchange connecting rods, cylinder liners, pistons, turbochargers, cam followers, fuel transfer pump, prelube pump, piston pins, scavenge oil pump, and main oil pump.
- Install new piston rings, main bearings, rod-bearings, valve rotators, and crankshaft seals.
- Inspect crankshaft for deflection, journal damage, and bearing material seized to the journal. At the same time, check the taper and profile of the crankshaft journals by interpreting the main and rod-bearing wear patterns.
- Inspect the camshaft for journal and/or lobe damage.

NOTE:
If camshafts or crankshafts are removed for any reason, use the magnetic particle inspection process to check the components for cracks.

- Inspect the cam bearings for fatigue and wear.
- If the damper is not damaged, it can be used again at overhaul.
- Inspect gear train gears and bushings for worn gear teeth, unusual fits and unusual wear.
- Upon reassembly of the drive line and driven equipment, check alignment.
- Clean and pressure test the oil cooler core and the aftercooler core.
- Obtain coolant analysis.

Refer to:

- Specifications: 3508B, 3512B and 3516B Engines (SENR6562-01) in Appendix 4.2.3.10.1.1.
- Operation and Maintenance Manual: 2500B Generator Set Engines and 3500 Generator Set Engines With EUI Option (SEBU69-16020) in Appendix 4.2.3.10.1.2.
- Systems Operation, Testing and Adjusting: 3500B Engines (SENR6563-01) in Appendix 4.2.3.10.1.3.
- Disassembly and Assembly: 3500B Diesel Engines (SENR6564-01) in Appendix 4.2.3.10.1.4.
- Troubleshooting: 3500B Generator Set Engines (SENR1003-03) in Appendix 4.2.3.10.1.5.
- Service Manual: 3500B Electronic Instrument Panel (SENR6587-01) in Appendix 4.2.3.10.1.6.
- Owner’s Manual: Customer Communication Module (CCM) for 3500B Engines (SEBU6997) in Appendix 4.2.3.10.1.7.
- Maintenance Management Schedules: Recommended Preventive Maintenance Schedule for Standby Generator Sets (SEBU6042-04) in Appendix 4.2.3.10.1.8.

3.4.9.1 Diesel Engines and Accessories

3.4.9.1.1 Diesel Engine

The engine is an electronically controlled diesel engine. The engine has built in diagnostics to ensure that all components are operating properly.

3.4.9.1.2 Engine Speed Governing System

The engine is equipped with an Electronic Control Module (ECM) that monitors engine operating conditions and initiates action if the engine exceeds an acceptable range. There are three possible actions: Warning, Derate, and Shutdown.

The ECM will automatically warn the operator and shut the engine down if an engine overspeed occurs. The engine overspeed indicator lamp illuminates when the ECM detects an overspeed condition.

3.4.9.1.3 Engine Protective Devices

It is impossible to tell if alarms and shutoff components are in good working order during normal operation. Engine malfunctions must be simulated in order to test these engine protective devices.

Conduct visual inspections to determine the condition of all gauges, sensors, and wiring. Look for loose, broken, or damaged wiring and components. Repair or replace any damaged wiring or components immediately.

NOTE:
During testing, abnormal operating conditions must be simulated. Perform the test correctly to prevent possible damage to the engine. Refer to the Service Manual for the testing procedure. See Appendix 4.2.3.10.1.6.

3.4.9.1.4 Engine Accessories

3.4.9.1.4.1 Block Heaters

Check for proper operation. Maintain 32°C (90°F) coolant temperature in the block at all times.

3.4.9.1.4.2 Air Filters

The service indicator will indicate when the air cleaner needs to be cleaned or replaced. The air cleaner element can be used up to six times if the element is properly cleaned and inspected.

Daily, inspect the service indicator for cracks, holes, or loose fittings. If necessary, repair or replace the service indicator.

Yearly, replace the service indicator, regardless of operating conditions. Replace the service indicator at Overhaul, and whenever major engine components are replaced.

NOTE:
Never operate the engine without an air cleaner installed. Never operate the engine with a damaged air cleaner. Do not use air cleaner elements with damaged pleats, gaskets, or seals. Dirt and debris that enters the engine causes premature wear and damage to the engine components. Air cleaners prevent airborne dirt and debris from entering the engine through the air inlet.

NOTE:
Never service the air cleaner with the engine running since this will allow dirt and debris to enter the engine.

NOTE:
When a new service indicator is installed, excessive force may crack the top of the service indicator. Tighten the service indicator to a torque of 2 N•m (18 lb. in).

Refer to the Operation and Maintenance Manual: 2500B Generator Set Engines and 3500 Generator Set Engines With EUI Option (SEBU69-16020) in Appendix 4.2.3.10.1.2.

3.4.9.2 Cooling System

Daily, check the coolant level. Inspect the cooling system for leaks and trash buildup. Inspect and clean the radiator and aftercooler fins of dirt and debris.

CAUTION:
Stop the engine and allow the engine to cool before performing this maintenance procedure. Check the coolant level only after the engine has been stopped and the cooling system filler cap is cool enough to touch with your bare hand.

Every 250 Service Hours, test SCA Concentration or obtain Level I Analysis (conventional HD coolant/antifreeze only).

WARNING:
Coolant additive contains alkali. To prevent personal injury, avoid contact with the skin and eyes. Do not drink coolant.

Every 3000 Service Hours or 2 Years, drain/clean/replace coolant (conventional HD coolant/antifreeze only).

NOTE:
Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

Every 6000 Service Hours, drain/flush/replace ELC (extended life coolant only).

3.4.9.2.1 Jacket Water

3.4.9.2.1.1 Jacket Water Piping/Valves

Perform piping/valve inspections as part of the overall jacket water system inspections.

3.4.9.2.1.2 Remote Radiators

Maintenance instructions for remote radiators (equipment #GS30014 through #GS30017) are as follows.

Motor: Lubricate ball bearings once per year, or every nine months for severe operating conditions. Clean ventilation openings as needed.

Fan: Clean fan blades once per year. Use stiff brush or air nozzle for loose dirt and non-flammable solvent with brush for solid deposits. Use care in cleaning fan blades; if damaged, an out-of-balance condition might cause vibration and damage to bearings of motor and/or fan bearing.

Fan Bearings (V-Belt and External Drive Systems): Lubricate fan and idler bearings once per year or more often for severe operating conditions.

Fan Drive. Check and maintain alignment of sheaves by adjusting their location on fan shaft and idler shaft. Check and maintain correct tension of fan belts by adjusting idler. Check for frame vibration due to fan imbalance, bearing wear, or loose drive components.

Core and Frame: Periodically check for core or plumbing leakage. Inspect MWC top tank or HC system high point for correct liquid level.

Test antifreeze coolant for correct specific gravity before cold weather. Examine interior MWC top tank through filler neck for signs of scale formation and rust. Radiator should be cleaned, flushed, and treated if necessary.

> **NOTE:**
> **Be careful that fins or tubes are not damaged from rough brushing or excessive jet pressure of either steam or air.**

Refer to Standard MWC and Standard HC Remote and External Drive Radiators catalog in Appendix 4.2.3.10.2.2.

3.4.9.3 Stack Gas

3.4.9.3.1 Engine Exhaust Piping/Valves

Perform visual inspections of piping as part of the exhaust system inspection.

3.4.9.3.2 Non-Heat Recovery Silencers

The non-heat recovery silencers are on the generator exhaust system (equipment #SY30042). Perform maintenance as part of the exhaust system inspection.

3.4.9.3.3 Heat Recovery Silencers

There are three exhaust heat recovery exchangers (equipment #EE30015 through #EE30017).

The heat recovery silencer has no moving parts and requires little routine maintenance. Periodically, the connections should be inspected for leak tightness and the soot should be cleaned from the unit. After cleaning, new gaskets should be installed.

Refer to Installation, Operation and Maintenance Instructions in Appendix 4.2.3.10.3.3.

3.4.9.4 Lubricating Oil System

3.4.9.4.1 Lubricating Oil Filters

Perform periodic filter replacement.

3.4.9.4.2 Lube Oil Piping/Valves

Perform visual inspections of piping/valves as part of the lubricating oil system inspection.

3.4.9.4.3 Lube Oil Reprocessing Module

Perform maintenance on the primary components of the lube oil reprocessing module (equipment #SY30040) as follows.

Centrifuge:

> **NOTE:**
>
> **Pre-Maintenance Checks**
>
> - **Be sure that the centrifuge has come to a complete stop before unscrewing the feed tube handle, loosening cover clamps, or initiating any disassembly or maintenance procedures.**
> - **Before performing any maintenance activities, make sure that the main electrical disconnect switch at the power supply panel is opened and locked out, or tagged out.**
> - **Be sure that the maintenance area and/or the area around the centrifuge is clean and free of loose gear, trash, oil spills, and/or grease spots.**
> - **Be sure that all tools and equipment necessary to the maintenance task are kept readily available near the work area, but not underfoot.**
> - **Be sure that plant services to the centrifuge, such as air and water, have been adequately secured before any maintenance tasks are undertaken.**

- Monitor corrosion and erosion to prevent hazardous conditions from developing.
- Monitor the threads of the bowl lock ring and bowl body to prevent unsafe operating conditions. Periodically inspect the bowl body for signs of pitting and cracking around the inside.
- Inspect the seal ring in the lower rim of the bowl hood and periodically replace in order to avoid the occurrence of high-flow, high-pressure leakage between the bowl hood and bowl body.
- Check spindle threads for corrosion and erosion.
- Check drive belts for wear and stretching. Regularly inspect the following drive components: pulleys, bushings, gears, gear boxes, gear trains, and guards.

- Change lubricants regularly.
- Inspect electrical connections for signs of corrosion, stress, looseness, and heat damage (discoloration and possible sparking).

Refer to Safety Manual For Alfa Laval® and De Laval® Centrifuges in Appendix 4.2.3.10.4.1.

Separator:

WARNING:
Separator parts that are worn beyond their safe limits or incorrectly assembled may cause severe damage or fatal injury.

Daily, check inlet and outlet device for leakage. Check separator bowl and belt transmission for vibration and noise. Check oil level of sump. Check electrical motor for heat, vibration, and noise.

CAUTION:
When excessive vibration occurs, keep bowl filled and stop separator. The cause of the vibration must be identified and corrected before the separator is restarted. Excessive vibration can be due to incorrect assembly or poor cleaning of the bowl.

Intermediate Service: Overhaul the separator bowl, inlet, and outlet every 3 months or 2000 operating hours. Renew seals in bowl and gaskets in the inlet/outlet device.

Major Service: Overhaul the complete separator every 12 months or 8000 operating hours. Perform Intermediate Service, and renew the flat belt, friction elements, seals, and bearings in the bottom part.

3-Year Service: Service the coupling bearings and the frame intermediate part, and renew frame feet. The rubber feet get harder with increased use and age.

Oil Change: Change oil and check belt transmission every 1500 hours of operation. When the separator is run for short periods, change the lubricating oil every 12 months even if the total number of operating hours is less than 1500. In seasonal operation, change the oil prior to a new period.

Refer to Separator Manual in Appendix 4.2.3.10.4.1.

Liquid Level Switches: Units are virtually maintenance free.

Y-Strainer: Clean basket when there is a 5 PSI increase in pressure loss across the strainer.

Pump: Mechanical seals (AM pumps) do not require adjustment. Check seal for wear, marring, or cracked rotating or stationary seal face, or for hard, soft, cracked, expanded, or extruded bellows. These conditions may cause seal leakage.

Motor: The motor is virtually maintenance free. Perform visual inspections to examine wiring connections and to prevent accumulation of dirt and foreign material.

Solenoid Valves:

WARNING:
Turn off electrical power supply and depressurize valve before making repairs. It is not necessary to remove the valve from the pipeline for repairs.

Periodically clean solenoid valves and inspect internal parts for damage or excessive wear.

3.4.9.5 Engine Fuel Oil System

3.4.9.5.1 Fuel Oil Filters

In-line fuel filters are provided in the generator fuel supply lines to prevent clogging and fouling from particulates in the fuel.

Periodically replace fuel filter to maintain fuel purity and adequate fuel flow.

3.4.10 Control Systems

3.4.10.1 Direct Digital Control and Monitoring Equipment

The direct digital area controller (equipment #PP30148, #PP30179 - #PP30186) has a built-in maintenance time reminder function to ensure system maintenance requirements are performed.

Refer to specifications and diagrams in Appendix 4.2.3.11.1.

3.4.10.2 Control Valves

Per manufacturer, this equipment does not require routine maintenance.

3.4.10.3 Damper Operators

No lubrication or periodic servicing is required. The case exterior and cover should be kept clean. Occasionally disconnect pressure lines to vent both sides of gage to atmosphere and re-zero.

3.4.10.4 Input/Output Sensors

Per manufacturer, this equipment does not require routine maintenance.

3.4.10.5 Transmitters

Per manufacturer, this equipment does not require routine maintenance.

3.5 ELECTRICAL SYSTEMS

3.5.1 Interior Distribution System

3.5.1.1 Panelboards

There are six panelboards (equipment #PP30142 through #PP30147) located throughout the New Power Plant for general electrical lighting and power distribution.

WARNING:
277/480 volts or 120/208 volts present within branch electrical distribution panelboards. Do not touch electrical connections before ensuring the power has been disconnected using an approved lockout/tagout and/or using insulated tools and proper personal protective equipment (PPE). Failure to do so can result in serious injury or death. Only qualified personnel should attempt the operation and maintenance of this equipment.

Perform maintenance in accordance with PM #6216FA.

Annually, check for faulty insulation and signs of overheating. Check terminals and ground connections. Check switches and breakers. Clean the panel interior.

Refer to diagrams in Appendix 4.2.4.1.1.

3.5.1.2 Motor Control Centers

Motor control centers (equipment #PP30149 and #PP30150) are the primary location of motor starters for New Power Plant equipment.

WARNING:
This equipment must be serviced only by qualified electrical personnel. Turn off all power supplying this equipment before working on or inside. Always use a properly rated voltage sensing device to confirm that power is off. Replace all devices, doors, and covers before turning on the power to this equipment. Failure to follow these instructions will result in death or serious injury.

CAUTION:
Never brush or use sandpaper on the bus; doing so will remove plating and cause oxidation. Use a cleaning fluid approved for such use. Do not use cleaning fluid on insulators. Do not attempt to clean bus bars or connectors that are damaged in any way. Replace them with new parts. Failure to follow these instructions can result in equipment damage.

Perform maintenance in accordance with PM #0190FA.

Clean the MCC. Perform maintenance of bus and incoming line lug connections. Inspect the stab assemblies for signs of arcing or overheating. Check for proper operation of the circuit breaker or disconnect switch, the operator mechanism, the starter contacts, control devices, overload relay, starter interlocks, and barriers/insulators. Inspect all fuses and fuse clips. Check all electrical connections and inspect all wiring.

Refer to the Instruction Bulletin in Appendix 4.2.4.1.2.

3.5.1.3 Uninterruptible Power Supply

The uninterruptible power supply (equipment #PD30060) requires minimal maintenance.

WARNING:
Lethal voltages may be present within this unit even when it is apparently not operating. Observe all cautions and warnings in the Liebert "User Manual" (Appendix 4.2.4.1.3). Failure to do so MAY result in serious injury or death. Refer UPS and battery service to qualified service personnel. Keep unauthorized personnel away. Never work alone.

Perform maintenance in accordance with PM #0114FA, #0114FQ and #0114FS.

Keep UPS clean and cool and occasionally vacuum dust from around ventilation grilles. Clean UPS with only a dry cloth. Do not use liquid or aerosol cleaning fluids. Check connections for tightness and any visible signs of overheating. Periodically check UPS operation by switching off utility power and observing the On Battery message. **Do this with only non-critical loads connected to the unit.** Note and correct any alarm messages indicated on the display.

WARNING:
Lead-acid batteries contain hazardous toxic materials. Handle, transport, and recycle in accordance with federal, state, and local regulations. DO NOT dispose of batteries by fire; they may explode. DO NOT open or mutilate batteries; released electrolyte is harmful to skin and eyes, maybe toxic. A battery presents a risk of electrical shock and high short circuit current. Lead-acid batteries present a risk of fire due to hydrogen gas generation.

WARNING:
Observe these precautions when working on batteries:

- **Remove watches, rings, or other metal objects.**
- **Wear rubber gloves and boots and use tools with insulated handles. DO NOT lay tools or metal parts on top of batteries.**
- **Unplug UPS prior to connecting or disconnecting battery terminals. Remove battery fuses or open battery circuit breaker.**
- **Remove all battery grounds. Contact with any part of a grounded battery may result in electrical shock.**
- **DO NOT SMOKE near batteries. DO NOT cause flame or spark in battery area.**
- **Touch a grounded metal surface to discharge static electricity from body before touching batteries.**

Periodically clean batteries with a clean dry cloth. Inspect all connections and tighten as required. Apply a thin film of battery grease to each connection.

Refer to User Manual in Appendix 4.2.4.1.3.

3.5.1.4 Enclosed Motor Controllers and Contactors

Motor controllers and contactors are utilized to provide overload protection and manual and/or automatic control of their associated loads.

WARNING:
277/480 volts or 120/208 volts present within the electrical motor controllers and/or contactors. Do not touch electrical connections before ensuring the power has been disconnected using an approved lockout/ tagout and/or using insulated tools and proper personal protective equipment (PPE). Failure to do so can result in serious injury or death. Only qualified personnel should attempt the operation and maintenance of this equipment.

Check equipment for proper operation. Inspect terminations for secureness and signs of overheating. Clean cabinet spaces. Check contacts for signs of thinness. DO NOT file contacts. Verify proper overload sizing in accordance with motor nameplate specifications.

3.5.1.5 Enclosed Disconnect Switches

Disconnect switches provide a means of isolating the electrical power supply from the load to support de-energizing during maintenance activities.

> **WARNING:**
> **277/480 volts or 120/208 volts present within the electrical disconnect switches. Do not touch electrical connections before ensuring the power has been disconnected using an approved lockout/tagout and/or using insulated tools and proper personal protective equipment (PPE). Failure to do so can result in serious injury or death. Only qualified personnel should attempt the operation and maintenance of this equipment.**

Verify on/off operation of the disconnect. Check terminations for secureness or signs of overheating. Clean cabinet.

3.5.2 Power Generation and Distribution

3.5.2.1 Unit Substations

The unit substation (equipment #PD30061) provides 5 kV electrical distribution power to South Pole ancillary facilities to compensate for voltage drop due to distance.

> **DANGER:**
> **HAZARD OF ELECTRICAL SHOCK, BURN OR EXPLOSION.**
>
> **Failure to observe these precautions will cause death or severe personal injury.**
>
> - **Only qualified personnel familiar with medium-voltage circuits are to perform work on this equipment.**
> - **For this equipment to function properly, it must be operated and maintained correctly.**
> - **Do not make any modifications or operate this equipment with interlocks removed.**
> - **Before performing visual inspections, tests, or maintenance on this equipment, disconnect all sources of electric power, and perform correct lockout & tagout procedures.**

Perform maintenance in accordance with PM #0205FA and as follows.

Switchgear: Perform inspection and maintenance based on operating conditions and experience. Periodic inspection of the HVL/cc metal-enclosed switchgear is necessary to establish baseline conditions.

After a circuit experiences a fault current or stressful condition, inspect the equipment before turning power back on; otherwise, the following can be used as a guide.

Maximum Interval for Preventive Maintenance

	Environmental Conditions		
	Ideal	**Standard**	**Aggressive**
Epoxy Switch Housing	No Attention	No Attention	Every 5 years
Housing Interior (bus and mechanism)	No Attention	No Attention	Every 5 years
Housing	No Attention	Every 5 years	Every 2 years

Refer to diagrams and Instruction Bulletin in Appendix 4.2.4.2.1.

Transformer:

DANGER

Hazard of Electrical Shock or Burn. Turn off power supplying this equipment before working on it. Never attempt to check the output voltage at the transformer since dangerous high voltage may be present within the transformer enclosure. Failure to observe this precaution will result in severe personal injury or death!

Perform inspection and maintenance based on operating conditions. Inspect for dirt, loose connections, the condition of tap changers or terminal boards, the general condition of the transformer, and tracking or carbonization indicating overheating and voltage creepage over insulating surfaces. Clean; check for rust and corrosion; and inspect fans, motors, and other auxiliary equipment.

Refer to Instruction Bulletin in Appendix 4.2.4.2.1.

3.5.2.2 Distribution Switchboards

The Preferred Main Distribution Equipment - PMDE (equipment #PD30064) and Redundant Main Distribution Equipment - RMDE (equipment #PD30065) provide primary and redundant electrical power to the Station buildings.

Maintenance should be performed per PM #0205FA.

<u>WARNING</u>:

HAZARD OF ELECTRIC SHOCK, BURN, OR EXPLOSION

- **Inspect and perform preventive maintenance only on switchboards and equipment to which power has been turned off, disconnected, and electrically isolated (unless otherwise specified) so that no accidental contact can be made with energized parts.**
- **Follow safety related work practices as described in NFPA 70E, Part II at all times.**

Failure to observe these instructions will result in death or serious injury.

Clean, lubricate, and exercise component parts. The interval between maintenance checks can vary depending on amount of usage and environmental condition. However, the maximum recommended inspection interval is one year.

<u>CAUTION</u>:

HAZARD OF EQUIPMENT DAMAGE

- **Do not use an air hose to blow out the switchboard. The dust may settle inside relays and overcurrent devices, causing overheating and improper operation.**
- **Do not allow paint, chemicals, or petroleum-based solvents to contact plastics or insulating materials.**

Failure to observe these instructions can result in injury or equipment damage.

Refer to Instruction Bulletin, Power-Style® QED Switchboards in Appendix 4.2.4.2.2.

The circuit monitor and Ethernet gateway do not require regular maintenance, and they do not contain any user-serviceable parts.

3.5.2.3 Automatic Paralleling Switchgear

The overall system control and sequencing of the generators is accomplished by the automatic paralleling switchgear. Each generator is controlled by its own panel designated GC-1, GC-2, GC-3 and GC-4 (equipment #GS30022, #GS30023, #GS30024 and #GS30025). Each of the generator control panels feed power to the generator master control panel designated GC-M (equipment #GS30026).

The System Display for MICROLOGIC® circuit breakers on the switchgear is designed for maximum reliability in harsh industrial environments and should require no maintenance when installed and used properly.

Refer to the Instruction Bulletin in Appendix 4.2.4.2.3.

DANGER:

HAZARD OF ELECTRIC SHOCK, BURN OR EXPLOSION

- **This equipment must be installed and serviced only by qualified electrical personnel.**
- **Turn off all power supplying this equipment before working on or inside equipment.**
- **Always use a properly rated voltage sensing device to confirm power is off.**
- **Replace all devices, doors, and covers before turning on power to this equipment.**

Failure to follow these instructions will result in death or serious injury.

Periodically and following any severe electrical fault, inspect SE electronic trip circuit breakers with MICROLOGIC® trip systems for loose power terminals, distorted connectors, or any loose parts in the switchboard section. Refer to Instruction Bulletin, SE Electronic Trip Circuit Breaker with MICROLOGIC® Trip System.

CAUTION:

HAZARD OF CIRCUIT BREAKER DAMAGE. Arc vents must be covered with tape before moving or servicing circuit breaker. If any object drops into arc vents, return circuit breaker to Square-D. Failure to follow these instructions can result in equipment damage.

3.5.2.4 Power Conditioning Equipment

The transient voltage surge suppressors (TVSS) are internal to the PMDE and RMDE switchgear. Each surge suppression module is individually fused for severe over-voltage swells and for high fault currents insuring safe operation.

Perform inspection and maintenance in conjunction with the distribution switchgear PM's.

3.5.2.5 Dry-Type Transformers

Like other electrical equipment, the transformers require maintenance from time to time to assure successful operation.

Perform inspection and maintenance in accordance with PM #0205FA.

> **WARNING:**
> **Hazard of Electrical Shock or Burn. Turn off power supplying this equipment before working on it. Never attempt to check the output voltage at the transformer since dangerous high voltage may be present within the transformer enclosure. Failure to observe this precaution will result in severe personal injury or death!**

With the transformer de-energized, inspect for dirt, loose connections, signs of overheating and voltage creepage over insulating surfaces, rust, and corrosion. Clean areas where accumulations of dirt are found.

Refer to Instruction Bulletin in Appendix 4.2.4.2.5.

3.5.3 Lighting

3.5.3.1 Site Lighting

Incandescent lighting fixtures are used throughout the exterior Power Plant building.

During performance of the annual building inspection (PM #0354FA), inspect lighting for proper operation. Verify lighting fixtures for illumination and verify switches/contactors for control of their respective fixtures.

3.5.3.2 Interior Luminaries

Four-foot, industrial, pendant-mounted fluorescent lighting fixtures provide lighting within the New Power Plant. During performance of the annual building inspection (PM #0354FA), inspect all interior lighting for proper operation. Verify lighting fixtures for illumination and verify switches for fixture control.

3.5.3.3 Emergency Lighting Units

Two types of emergency lighting units are provided to facilitate emergency egress.

Exterior emergency lighting is provided by a 120VAC emergency lighting power source (equipment #LI30270 and #LI30271) that provides 12 volts from a battery back-up to the remote emergency lights in the event of a power failure.

Interior emergency lighting units (equipment #LI30275 through #LI30306) consist of 120VAC self-contained units complete with two integral lighting heads, maintenance-free batteries, and recharging capabilities.

In accordance with NFPA 101, "Life Safety Code," conduct periodic testing of the emergency lighting units.

Monthly, depress and hold the test button for a minimum of 30 seconds. The voltmeter should indicate approximately 12 volts for the entire 30 seconds.

> **NOTE:**
> **It is normal to get a reading of less than 12 volts if a power failure has occurred shortly before the test.**

Annually, inspect battery for visible signs of corrosion or physical damage and clean. Check connections. Conduct a functional test for a 1-1/2 hour duration. In accordance with NFPA 101, all emergency lighting units must remain illuminated for the entire duration.

3.5.3.4 Exit Lighting/Signs

Exit lights within the Arch (equipment #LI30266 through #LI30269) are self-luminous tritium-filled pyrex tubes. Perform maintenance in accordance with PM #0124FA.

Annually, ensure nothing impairs visibility of the exit sign and cleaning of the unit. Verify that tubes are intact. If the seal of the tubes is compromised, call the Safety, Environment and Health Coordinator.

The exit sign lighting within the building is 120VAC fluorescent with DC lamp battery back-up. Inspect exit sign lights (equipment #LI30272 through #LI30274) for operation, cleanliness, and visibility in accordance with PM #6735FM.

3.5.4 Motors (refer to Specific Motor Operated Equipment)

3.5.5 Engine-Generator Set/Generator Systems

WARNING:
The stop-manual automatic switch on the cranking panel must be set at "stop" position when performing maintenance or repair work on a standby generator set. This prevents the unit from starting if a power failure or voltage drop should occur while working on the unit.

To prevent person injury due to accidental starting of the engine, disconnect the batteries or disable the starting system before doing maintenance or repair work.

Lockout all switchgear and automatic transfer switches associated with the generators while performing any generator maintenance or repairs. Ensure no shock hazard exists.

Failure to comply could result in personal injury or death.

Periodically generators should be inspected for cleanliness. Do not allow contaminants such as dirt, dust, grease, salt, or oil films to accumulate on generator windings

WARNING:
Before working inside the generator, make sure that the starter motor can not be activated by any automatic or manual signal.

When the engine-generator is operating, voltages up to 600V are present in these areas near or on the regulator:

- **The regulator terminal strip.**
- **The excitation transformer terminal strip (PM-excited generator only).**

Do not short these terminals to ground with any part of the body or any conductive material. Loss of life or injury could result from electrical shock or injury from molten metal.

NOTE:
Electronic components in the regulator can be damaged during generator operation if contact is made between the part and ground.

Clean the voltage regulator and generator of dirt and debris. Use a brush to loosen accumulations of dirt and a vacuum system for removal.

Visually check for loose or broken wires and connections. Check the wires and connections on the voltage regulator assembly. Check all wires and connections in the generator. Clean heat sinks.

Make any necessary repairs to the wiring as required.

Periodically use a megohmmeter (megger) to check generator main stator winding insulation resistance.

Inspect and lubricate bearings at every major engine overhaul.

Refer to:

- Operation and Maintenance Manual: SR4B Generators and Control Panels (SEBU6918) in Appendix 4.2.4.5.1.1.
- Service Manual: SR4 Generator (SENR7968-03) in Appendix 4.2.4.5.1.2.
- Service Manual: Generator Set Load Sensor and Load Sharing Module (SENR6565-01) in Appendix 4.2.4.5.1.3.
- Service Manual: Digital Voltage Regulator (SENR5833-01) in Appendix 4.2.4.5.1.4.
- Service Manual: Programmable Relay Control Module (PRCM) (SENR6588-02) in Appendix 4.2.4.5.1.5.

3.5.5.1 Engine-Generator Set Controls

3.5.5.1.1 Engine Control Panel

The generator set Electronic Modular Control Panel II (EMCP II) is located on top of the generator regulator housing. The control panel consists of a main panel with indicators, meters and control switches.

WARNING:
When the engine-generator, or any source to which the engine-generator is synchronized to, is operating, voltages up to 600 volts are present in the control panel.

DO NOT short these terminals with line voltage to ground with any part of the body or any conductive material. Loss of life or injury could result from electrical shock or injury from molten metal.

This panel is equipped with self-diagnostics and does not require supplemental maintenance.

3.5.5.1.2 Generator Control Panel

Refer to Section 3.5.2.3 (Automatic Paralleling Switchgear).

3.5.5.1.3 Generator Control/Start Batteries

> **WARNING:**
> **Lead-acid batteries contain hazardous toxic materials. Handle, transport, and recycle in accordance with federal, state, and local regulations. DO NOT dispose of batteries by fire; they may explode. DO NOT open or mutilate batteries; released electrolyte is harmful to skin and eyes, maybe toxic. A battery presents a risk of electrical shock and high short circuit current. Lead-acid batteries present a risk of fire due to hydrogen gas generation.**

> **WARNING:**
> **Observe these precautions when working on batteries:**
>
> - **Remove watches, rings, or other metal objects.**
> - **Wear rubber gloves and boots and use tools with insulated handles. DO NOT lay tools or metal parts on top of batteries.**
> - **Remove all battery grounds. Contact with any part of a grounded battery may result in electrical shock.**
> - **DO NOT SMOKE near batteries. DO NOT cause flame or spark in battery area.**
> - **Touch a grounded metal surface to discharge static electricity from body before touching batteries.**

Generator control/start batteries electrolyte levels should be checked every 1000 hours and water added as required. Clean battery cases with a clean dry cloth. Check terminations for corrosion and loose terminations. Secure terminations/connections as required. Apply a thin film of battery grease to all terminations.

> **IMPORTANT:**
> **Check battery water level frequently. Low water levels will damage batteries.**

3.5.5.1.4 Control/Start Battery Charger

The control/start battery chargers are fully automatic equalizing chargers. This ensures that the batteries are completely recharged and not cycled.

Perform maintenance for the battery chargers (equipment #GS30018 through #GS30021) in accordance with PM #6526FA.

WARNING:
Power must be disconnected before opening cover to avoid shock and potential for explosion or fire.

No maintenance is required other than cleaning of the outside cabinet. A dry cloth can be used. Occasionally, check all connections for tightness. No adjustments are normally required. However, voltage adjustments can be made if needed.

3.5.6 Heat Trace

3.5.6.1 Vent-Thru-Roof, Force Main Discharge, Exterior Water Pipe Heat Trace

Perform maintenance for the Auto-Trace heat-tracing system (equipment #SY30032) in accordance with PM #6862FA. Visually inspect the pipe, insulation, and heating cable connections to ensure that no physical damage has occurred. Megger the system to determine whether damage has occurred that may not be readily visible.

For systems controlled by line-sensing thermostats, check the system at least twice a year. Systems controlled by ambient-sensing thermostats should be checked before each winter.

Refer to Installation and Maintenance Guide in Appendix 4.2.4.6.1.

3.5.7 Signaling Systems

3.5.7.1 Telephone

Telephone service is provided to the New Power Plant via the BIOMED Communications Hub. A dedicated phone line is provided for the paging system amplifier. Telephone system operability shall be verified during master Information Systems telephone preventative maintenance (PM #PM0010). PABX system and cabling shall be checked to the New Power Plant. Specific phone connection will not be checked.

3.5.7.2 Public Address System

A public address amplifier is located within the New Power Plant to provide local annunciation within the New Power Plant. Loudspeakers are located throughout the New Power Plant. A paging relay is utilized to allow paging from the phone system over the various loudspeakers.

Public Address system operability shall be verified during All-Call preventative maintenance.

The All-Call system for the New Power Plant is located in the BIOMED Communications Hub.

3.5.7.3 Local Area Network (LAN)

Network (LAN) service is provided to the New Power Plant via the BIOMED Communications Hub. LAN system operability shall be verified during Data Systems preventative maintenance (PM #PM0099). Specific LAN connections will not be checked.

3.5.7.4 Video Surveillance (Future)

3.5.7.5 CCTV (Future)

3.5.7.6 Fire Detection and Alarm Systems

In compliance with NFPA 72H, Chapter 3 (Periodic Equipment and Circuit Testing Procedures), perform periodic tests of the fire alarm system in accordance with the schedules in Chapter 4 (Recommended Schedules and Methods for Testing Procedures). Because the fire detection and alarm system is not used on a routine basis, when called upon to work, it must work properly the first time.

To comply with the requirements of NFPA 72H and ensure the system will function properly, periodic inspection, testing, and maintenance of the fire detection and alarm system is performed monthly in accordance with PM #0132FM, semi-annually in accordance with PM #0132FS, and annually in accordance with PM #0132FA.

3.5.7.6.1 Fire Alarm and Detection Control Panel

The Fire Alarm Control Panel (equipment #AP30025) is a microprocessor-based advanced protection system located within the New Power Plant. It utilizes both analog and conventional detection devices. All modules and devices annunciated on the control panel are identified by an address. The system enables a qualified technician to test the operation of input points with or without disabling the entire fire alarm system. Testing can be silent or with audible feedback. Alarm/Trouble/Supervisory conditions are transmitted and received in the COMMS building (BL002).

Refer to the MXL-IQ Control Panel Operation, Installation and Maintenance Manual in Appendix 4.2.4.7.6.1.

Periodic inspections and testing of the fire alarm control panel are as follows:

Inspections:

> **NOTE:**
> **An inspection is a visual examination of the fire detection and alarm system to verify that it appears to be in good operating condition and free of physical damage. The visual inspection is generally done from floor level by walking through the protected premises.**

Perform monthly, semi-annual, and annual inspections of the fire alarm control panel in accordance with PM #0132FM, PM #0132FS, and PM #0132FA, respectively. Results shall be documented on Forms 1-A and 1-B. (Refer to Appendix 4.2.4.7.6.)

Monthly:

- Check fire alarm equipment to make sure it is not damaged or inoperative.
- Check power supply for normal indication.
- Illuminate lamps and light emitting diodes (LEDs) on fire alarm panel.

Semi-Annually:

- Check voltage of each rechargeable battery.
- Clean and inspect battery connections of lead acid batteries.
- Remove fuses, check ratings, and re-install.

Testing:

Perform monthly, semi-annual, and annual tests of the fire alarm control panel in accordance with PM #0132FM, PM #0132FS, and PM #0132FA, respectively. Results shall be documented on Forms 1-C, 1-E, 1-F, and 1-G. (Refer to Appendix 4.2.4.7.6.)

> **WARNING:**
> **Do not touch electrical connections before you first ensure that power has been disconnected utilizing an approved lockout/tagout and/or proper personal protective equipment (PPE) is utilized. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the operation and maintenance of this equipment.**

> **<u>CAUTION</u>:**
> **Before beginning tests, all parties, which may receive an alarm signal, should be notified so that there will not be an unnecessary response. At the conclusion of testing, all parties should again be notified. All equipment should be returned to normal condition and control panels locked.**

Monthly:

- Test the primary 120VAC power supply controlled by circuit breaker. Disconnect the primary power and verify fire alarm system switches normally to the secondary (battery) power source.
- Activate one device on each initiating device circuit.
- Activate notification appliance circuits and confirm proper operation of all audible and visual alarms.
- Test the supervisory device circuit by disconnecting a conductor from its terminal in the control panel. Once a trouble signal is received, re-connect the wire to its terminal and reset the control panel. Repeat the test for all supervised circuits.

Semi-Annually:

- Test each manual station.
- Activate extinguishing system alarm switches.
- Activate supervisory signal initiating devices (e.g., gate valve switches, high/low air pressure switches, temperature sensors, water level).
- Test the supervisory device circuit by disconnecting a conductor from its terminal in the control panel. Once a trouble signal is received, re-connect the wire to its terminal and reset the control panel. Repeat the test for all supervised circuits.
- Measure open circuit voltage of lead acid batteries.
- Test 10% of rate-of-rise heat detectors. (Test a different 10% each 6 months so that all detectors are tested within 5 years.)
- Test 10% of rate compensation heat detectors. (Test a different 10% each 6 months so that all detectors are tested within 5 years.)

Annually:

- Test each alarm initiating and signaling circuit for trouble signals.
- Activate alarm notification appliances.
- Confirm operation of all audible and visible alarm notification appliances.
- Test the supervisory device circuit by disconnecting a conductor from its terminal in the control panel. Once a trouble signal is received, re-connect the wire to its terminal and reset the control panel. Repeat the test for all supervised circuits.
- Test lamps and LEDs.
- Remove fuses and verify ratings and supervision.
- Measure open circuit voltage of lead acid batteries.
- Measure battery voltage under full load with battery charger disconnected.
- Check operation of battery charger.
- Test all control unit functions.
- Verify primary power supply. (Disconnect all secondary power and test under maximum load, including all alarm appliances operating for 5 minutes. Re-connect all power supplies at end of tests.)
- Disconnect primary power supply to test secondary power supply. Verify that the control panel operates properly from secondary power. Verify that trouble indicator comes on upon primary power loss. Measure standby current. Test system under maximum load, including all alarm appliances operating for 5 minutes. Re-connect all power supplies at end of tests.

3.5.7.6.2 Initiating Devices

All alarm initiating appliances (e.g., manual stations, fire detectors, pressure switches, flow switches) are interconnected and controlled by the Fire Alarm Control Panel located within the New Power Plant. Monthly inspections of the fire alarm initiating appliances shall be performed in accordance with PM #0132FM. Results shall be documented on Form 1-A. (Refer to Appendix 4.2.4.7.6.)

Monthly:

- Check all manual stations for damage or obstruction.
- Check all detectors for damage and obstruction. Obstruction means that the detector is located in a dead air pocket, is too close to an air handling unit discharge outlet, covers too large a space, or is blocked by storage.

Test the fire alarm initiating appliances during the performance of the monthly, semi-annual, and annual tests of the fire alarm control panel in accordance with PM #0132FM, PM #0132FS, and PM #0132FA, respectively. Results shall be documented on Forms 1-C, 1-E, 1-F, and 1-G. (Refer to Appendix 4.2.4.7.6.)

3.5.7.6.3 Signaling Appliances

All alarm signaling/notification appliances (e.g., audible and/or visible alarm signal devices) are interconnected and controlled by the Fire Alarm Control Panel located within the New Power Plant. Perform monthly and semi-annual inspections of the fire alarm signaling/notification appliances in accordance with PM #0132FM and PM #0132FS, respectively. Results shall be documented on Forms 1-A and 1-B. (Refer to Appendix 4.2.4.7.6.)

Monthly:

- Check all audible and/or visual alarm signal devices for damage or obstruction.

Perform testing of the fire alarm signaling/notification appliances during the monthly, semi-annual, and annual tests of the fire alarm control panel in accordance with PM #0132FM, PM #0132FS, and PM #0132FA, respectively. Results shall be documented on Forms 1-C, 1-E, 1-F, and 1-G. (Refer to Appendix 4.2.4.7.6.)

3.5.7.6.4 Auxiliary Devices

Perform monthly, semi-annual, and annual inspections of the fire alarm auxiliary devices (e.g., supervisory air switches, tamper switches) in accordance with PM #0132FM, PM #0132FS, and PM #0132FA, respectively.